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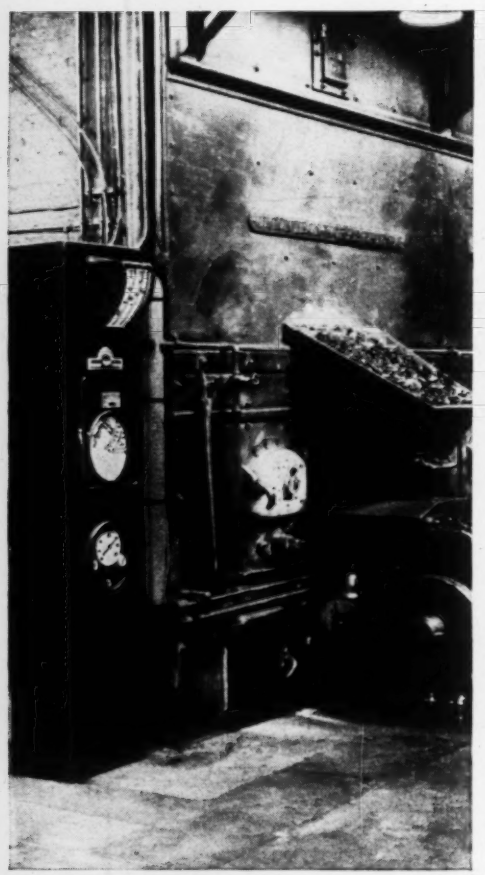

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MECHANICAL ENGINEERING

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VOLUME 69 NUMBER 7

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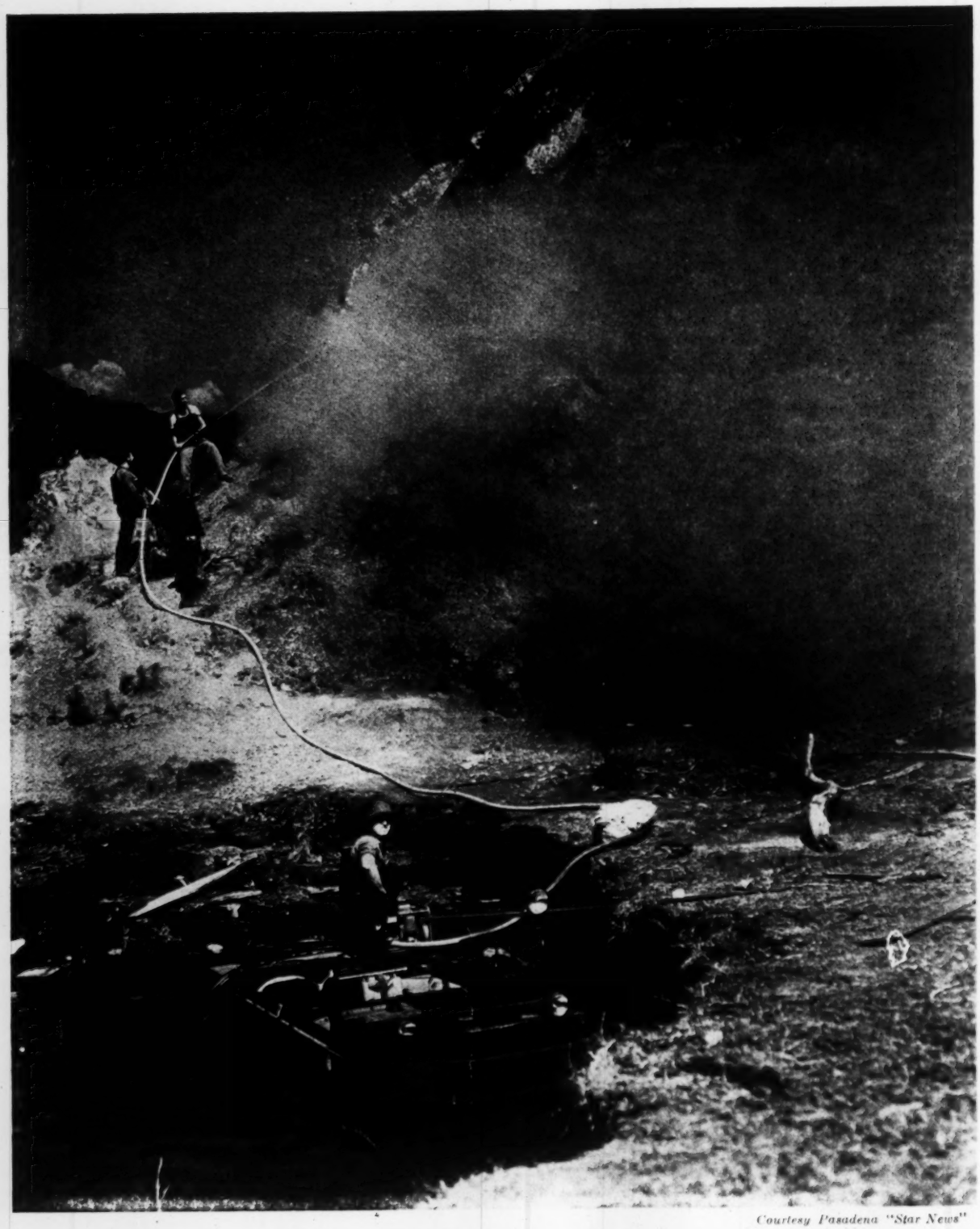

Courtesy Pasadena "Star News"

Demonstration of Army Cargo Carrier M29C Amphibious Weasel With Portable Pump on Lakeside Brush Fire

(This is one of the developments in forest-fire-control equipment discussed by Ira C. Funk in his article on page 544.)

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No. 7

MECHANICAL ENGINEERING

JULY
1947

GEORGE A. STETSON, *Editor*

Preparedness

ANY report to which the names of Karl T. Compton and Charles E. Wilson are signed must demand the respectful attention of engineers. And it will add materially to the prestige of the engineering profession that two members of The American Society of Mechanical Engineers, the distinguished president of the Massachusetts Institute of Technology and the dynamic president of the General Electric Company were chosen by the President of the United States as members of his Advisory Commission on Universal Training, whose report was made public June 1.

Few engineers will have failed by this time to have read the report. Regardless of what disposition is made of it by the Congress, the report represents a distinct break with the traditional peacetime policy of the United States. It emphasizes the fact that owing to world conditions, as the result of the late war, the uncertainty of the future, and the vastly changed conditions under which the world lives today, with its conflicting philosophies of life, its shrunken distances, the disappearance of natural barriers to attack, and the possibilities of an aggressor's being able successfully to wage brief, terrifying, and completely devastating total warfare, we are facing an insistent demand that the nation be prepared vigorously and effectively to defend itself practically at instant notice.

It would be foolhardy not to accept in principle the recommendations of the Commission, distasteful and costly as they may be. It has been this nation's conviction in the past that its fortunate geographical position, with two oceans separating it from Europe and the Orient, with peaceful neighbors on the north, and ones to the south with whom efforts to live in neighborliness have been reasonably successful, has spared it the necessity of maintaining large and expensive military establishments and requiring universal military training for all its male citizens. Today this conviction has been dissipated. Stern realities have brought in its place a conviction that we are vulnerable to attack and hence we must prepare ourselves to anticipate attack, to meet that attack instantly, if it should come, and, more probably, to place ourselves in such a position of strength and preparedness that no other nation will dare to make the attempt.

As to the eight "essentials" of the program for national security recommended in the report, each citizen must make his own appraisal of their validity and importance. "A strong, united, healthy, and informed nation—our number-one security requirement" is as important to a people in peacetime as it is to a people fearing attack. Unless these conditions are realized at home neither our efforts to influence other nations to embrace democratic forms of government, which in itself would constitute a strong defense measure, nor our ability to move quickly into defensive action in case of attack, would be effective. Engineers as citizens will heartily applaud this recommendation.

"A co-ordinated intelligence service" is scarcely a function with which private citizens would be intimately concerned except in cases where technological developments in other countries which come to the notice of engineers might suggest possible military uses or indicate ostensible peacetime developments that could be quickly converted to military uses.

As for the third point, "scientific research and development," engineers individually and in groups will constitute a considerable portion of the personnel of organizations which will be concerned with the task undertaken by the already established Atomic Energy Commission and with hundreds of projects that will be launched once the proposed National Science Foundation is approved by the Congress, to say nothing of projects already in progress under the Army and Navy research programs.

"Industrial mobilization," the fourth point, is a preparedness measure close to the interests of engineers because of their key positions in industry. It will be recalled that between World Wars I and II such a plan was made and educational orders for military equipment were placed with certain firms. Plans for "M-Day" were carefully laid out and a full-dress rehearsal was conducted in the Engineering Societies Building in New York, N. Y. The Commission's recommendations go further and include a start "toward decentralizing the most vital plants, and, in some cases, toward building underground or otherwise adequately protected facilities. Critical materials must be stockpiled now and in the future." In these matters the engineer is destined to play an important role.

The fifth recommendation, "a striking Air Force," implies developments in aeronautics and the design and production of airplanes and related equipment which are in the province of the engineer. In this connection it must be remembered that new types of airplanes do not flow immediately from the mind of the designer to the end of the production line. As was pointed out by Generals Chidlaw and Rawlings at the 1946 A.S.M.E. Aviation Meeting, "every plane and engine actually used in combat during the past war . . . . . were designed prior to Pearl Harbor." The equipment for a striking

air force must be designed and tested in peacetime if it is to be effective in wartime.

Engineers are also concerned in the design and construction of other types of equipment necessary for "other elements of the regular Army, Navy, Air Forces, Marine Corps, and Merchant Marine," the sixth point of the report, and in the seventh, "unification of the Armed Forces."

Quite the most revolutionary recommendation of the report is the last, "universal training," Here, undoubtedly, is a distinct break with tradition and a subject on which there will be honest differences of opinion. If reluctantly we accept this recommendation, we shall be guided by the cogent reasons set forth in the report, and we shall be encouraged to do so by the success of the program under development at Fort Knox, Ky., about which a brief account will be found in the A.S.M.E. News section of this issue, where an intelligent start has been made in securing the best results and guarding against some of the hazards that this way of life may hold for young men. The choice seems inevitable, for, as the report concludes: "A weak and irresolute America is an invitation to failure. A strong and resolute America is the best guarantee for our safety and for the success of the United Nations."

As citizens and as engineers we have a vital stake in the decisions to be taken in respect to the Commission's report. Let us view it objectively and not shrink from the consequences. Our future may depend upon it.

Engineers and History

THE critics of engineers, of whom a majority are made up of engineering teachers and engineers themselves, are constantly reminding us that engineers neglect large areas of human knowledge. Because the practice of engineering demands a mastery of the physical sciences and engineering principles and their application in a few specialized fields, engineering curricula are said to be too crowded to admit studies in the social sciences and in such important subjects as literature, philosophy, and history. The criticism and the explanation are both valid, and there is no lack of plans and proposals to better the situation. On the other hand, one may justly question whether engineers are more narrowly educated than any other group of professional men and whether their deficiencies of knowledge are any more serious than the deficiencies in the fields of science that are found in men who have benefited from a more general education or one directed to social and humanistic studies. The problem which the professions and all educated persons face is one of proper balance and intelligent understanding, of learning a lot about a little and something about almost everything. The problem of the colleges is how to set up educational programs that develop neither narrow specialists—whether in Sanskrit or nuclear physics—nor personable dilettantes unable to make a useful contribution to any field of human affairs, and to do this in a relatively few years. It seems obvious that it is the task of the college not to expose its students to every course it has to offer, which would be impossible, but to assist men to discover and develop their special aptitudes and interests and to stimulate the spirit of inquiry so that they can ever broaden their understanding of the world in which they live and the people who inhabit it.

That history is a subject which broadens one's understanding of human affairs, places the individual in proper relationship to them, and teaches the lessons of patience and humility, few will deny. In the perspective of history the consequences of men's actions are made more clear to those who study them, the engineer no less than others. There is always a possibility that the proper interpretation of the events of the past may lead men to conduct their affairs in the present so that the future may bring them greater happiness and satisfaction. Countless examples could be cited to show that men have profited from the lessons of history. As more intelligence and greater objectivity are brought to this study, the brighter are the prospects that we may learn from the mistakes of the past. This task is made more difficult because conditions change constantly and history does not repeat itself. Science and engineering have produced a world in which time and distance are vastly shortened and the way of life of western nations is subject to influences that were not particularly important a century ago. Modern history is being conditioned by influences which science and engineering have created. The sobering thought for engineers is that future historians will praise or blame engineers for the trends which the history of the human race will be forced to record in the future.

Unless many hours are to be added to the engineering curriculum, it is not likely that courses in history will be a very extensive part of the formal education of the engineer. Engineers must acquire a sense of the significance and importance of history by other means. With the mind alerted, as it can be by wise teaching of even highly technical subjects and the natural curiosity of an educated man, there is nothing but lack of interest to prevent the engineer from acquiring a taste for history and the habit of viewing events in the historical perspective. In addition to a vast amount of personal satisfaction, the engineer will find in the study of history a means by which he can assess the significance of his profession and help to shape its ideals and its services to the making of a world in which his technical achievements can be enjoyed by peaceful nations.

In an article in this issue Dr. Sears speaks of the engineer as "the fashioner rather than the interpreter of history" and repeats the charge that "perhaps he has been concerned too little with the wider implications of his work." By trying to understand the lessons of the past which history teaches, the engineer will come to sense some of those implications. The subject is not barred from his reading, even if it may be, except in brief, from his curriculum. With this enrichment of his knowledge he may "join with the historians in a partnership to which each brings fruitful gifts," and the criticism that the engineer neglects certain fields of knowledge in favor of his own specialty will no longer be valid.

The WORLD *the* MANAGER LIVES IN

By R. E. GILLMOR

SPERRY CORPORATION, NEW YORK, N. Y. MEMBER A.S.M.E.

ELTON MAYO,[1] in his penetrating book, "The Social Problems of an Industrial Civilization," says, "We face a world pitifully changed—in Europe, cities reduced to rubble and utter human chaos; in Asia and the Pacific Islands, an awakened and uncertain multitude, totally unprepared for the heavy responsibilities that face them. In eastern Europe, as in China, the peasant, thoroughly aroused from his passivity and seeming content, is demanding a higher standard of living. And, as ever in the primitive human, he believes that it is to be had for the asking, if the asking be sufficiently vociferous. A higher standard, as something constantly recreated or earned, is not within his comprehension; if it is not forthcoming, he will easily be persuaded that someone—American or plutodemocrat or capitalist—is deliberately withholding it from him." This, in a few words, is our external environment.

Internally, our material welfare is relatively satisfactory, but our social order is threatened by a tendency to break down into groups which show an ever-increasing hostility to each other; irrational hates taking the place of co-operation. This, historically, has heralded the downfall of many valiant civilizations.

UNBALANCE BETWEEN TECHNICAL AND SOCIAL SKILLS

All of the adverse conditions we face, both externally and internally, have arisen from the unbalance between our technical and social skills. We have learned how to add enormously to our power, but have not learned how to secure co-operation between people in the utilization of that power. The consequence is that a great part of the gains we make by improved technical skills are thrown away by destructive wars, industrial strife, and low individual efficiency.

It is probably inevitable that this unbalance between technical and social skills should have occurred, and may become worse before it is better. Phillippe Le Corbeiller, in the *Atlantic Monthly* of December, 1946, discussed the theory of Auguste Comte of more than a hundred years ago which states that there is an inevitable order in which the sciences and the applied arts must develop, each being dependent upon all the sciences which preceded it, but independent of those which follow. Mathematics came first, because it is the simplest, most exact, and the most easily proved; physics next, because it evolved logically and inevitably from mathematics. Mathematics and physics made it possible to develop chemistry as a science. Mathematics, physics, and chemistry are now making possible the development of a true science of biology, with exact laws verifiable by observation. The preceding sciences provide the basis for a quantitative science of psychology. And last will come a science of sociology. Sociology is now so far from being a science that we think of it as an abstraction of the academician, or a tool of the social worker, although at least one of its branches—economics—is now approaching the status of a science. Le Corbeiller thinks that eventually all of the sciences will merge into one great comprehensive science, a sort of supersociology, just as mathematics, physics, and chemistry are now beginning to merge.

Whatever the future may hold, the present indications are that we are in a very crucial period, during which it will be determined whether men must forego their freedom in order to regain their social solidarity, or can develop their social skill fast enough to retain their freedom. Individual freedom and social solidarity have always been in conflict. Man is an individualist by nature, but in order to survive against the forces of Nature, and the competition of other animals, he has been obliged to develop group co-operation.

The conflict between individualism and essential co-operation has been reconciled in the past by the development of forms of society in which the individual knew from birth what was expected of him, and therefore felt that his place in the social order was assured. In ancient civilization, and in the American and European communities of a century or more ago, group codes determined the social order, and the direction of individuals' lives. The individual willingly subordinated himself to the interest of the group, and in return the group gave him stability, an assured function, and an opportunity for satisfying participation.

The surnames of most of us are the result of this established form of society; so also are the deep-seated instincts which make us all desire participation, recognition, and the approval of our associates; for it is by these tokens of co-operation that the human race has survived and become the master being on this earth.

SOCIAL RESPONSIBILITIES OF INDUSTRY

In contrast to the established society, the typical industrial community of today is what Mayo calls "an adaptive society, composed of individuals of varied origin, many of them moving from one group to another in quest of education and jobs, many more encountering difficulty in relating themselves to others, with consequent feelings of solitariness and unhappiness." As industrial units have become larger, the significance of the individual has become less. He has reacted with wariness and hostility, and this reaction has led him to join groups that he feels will protect him. The groups take on the hostilities of their members, and thus society tends toward a condition of stasis—the confused struggle of pressure groups—which Casson claims has always heralded the approach of social disaster.

Management has, for the most part, been preoccupied with the technical phases of its business; the development of new products or services, and the improvement of the old, meeting or surpassing competition in quality, cost and distribution, increasing the profits, size, and security of the business. All these are measurable and result in commendation when they are good, and condemnation when they are bad. On the other hand, there are no adequate measures of the social and human factors. Management frequently makes the erroneous assump-

[1] "The Social Problems of an Industrial Civilization," by Elton Mayo, Harvard University, Division of Research, Cambridge, Mass., 1945.

tion that money is the principal source of incentive and satisfaction to the individual, and when this proves to be untrue blames the bad results on the union, the Government, or human cussedness. Communication between management and the worker is impeded not only by the preoccupations and assumptions of management, but also by the tendency of management to form groups of its own, which frequently build up antagonisms toward the labor groups, thereby still further adding to the danger of stasis. The fears of all groups within industry are further added to by the persistent tendencies of free society toward economic instability.

The inadequacies of our social skills and the tendency toward economic instability create an atmosphere which is favorable to the growth of ideologies such as socialism and communism; for these ideologies seem to promise greater recognition, participation, and security to the individual, and identification of his aspirations with the aspirations of a great and powerful group—the state. All these ideologies are of course medieval and rigid and in various forms have been proved unsuccessful time and again. However, it is unwise to ignore their appeal to a society in which the majority of individuals feel lost and insecure.

Our own democracy is unquestionably the most superior form of government that has ever been evolved. It approximates the form which natural laws have evolved for the government of organisms, as, for example, the two-hundred-billion cell population of the human organism. As Mayo says, "During a national emergency—depression, war, pestilence, flood, famine—the central authority assumes powers, for the time being, as arbitrary as those of a tyrant. But when the emergency passes, the central authority is released, and the locus of authority again passes to the peripheral organizations. . . . It is always in the informal groups at the working bench and elsewhere that spontaneity of co-operation originates. The central and peripheral authorities thus supplement and complete each other—logical and purposive control from above, spontaneous and co-operative control from below. Historically speaking, the great democracies represent a quest for wisdom in control rather than authority, an attempt to set the locus of decision in any difficulty approximately where the situation demands that it be placed. Full expression by the groups affected is as important as a logical and purposive scheme framed by the few who possess high technical skill. For a society must secure the effective participation and co-operation of everyone in addition to the contrivance of technical advance."

But Mayo also says that there are at least three limiting conditions which determine whether or not a democratic form of government can continue to be successful. These are (1) widespread technical skill and literacy, (2) no great extremes in the material standards of living and a sufficiently high standard so that those who work very hard in the lower economic levels will have enough for their organic and social needs, (3) a minimum of group hostilities and hatreds. We still have a reasonable degree of all of these conditions. We therefore have the most flexible and effective form of government that has yet been evolved. We are the only nation in the world whose people are rich enough, literate enough, and reasonable enough to be able to take the responsibility for maintaining peace in the world and leading it toward greater social stability and economic security. There was a *Pax Romana*. There was a *Pax Britannica*. There must be a *Pax Americana*.

But to fulfill our responsibility, we must arrest the trend toward social instability in our own country. With few exceptions, the leadership of the financiers has disappeared; the command of wealth will never again in our lifetimes, or those of our children, give control over the lives of human beings. This control by wealth was quite possibly an essential phase of our national development, but it had some black pages in its history, which gave the pendulum the push which swung it to the New Deal and the antibusiness legislation of the 1930's. For a time it looked as if our democratic form of government was in real danger. The packing of the Supreme Court, the purging and discrediting of Congress, the growth of government agencies, all pointed in that direction.

Walter Lippmann in his interpretation of a recent *Fortune Magazine* poll, drew the conclusion that the American people are indifferent to their Government because they do not base their expectations in life on what the Government does. This has its danger, as it makes it possible for a dictatorial-minded administration to encroach gradually upon the rights of the people and convert our polyphasic form of government into a monophasic or dictatorial form. It also makes it possible for government to be inefficient and wasteful.

MANAGEMENT ASSUMING NEW ROLE IN SOCIAL ORDER

The New Deal did not alter our form of government materially, but it did place the labor leaders in a position of great power—a power which they misused. As a reaction from the past, American management is now coming into power at a time when it can be said without exaggeration that the fate of American and of world civilization will depend upon what it does with its power. Another reason for the extension of the power of management is the increasing need for the specialized training and experience of the professional managers as industrial problems become more complex.

Management's most important problem is the development of the social skill of which Mayo speaks so eloquently, and of which he gives so many interesting examples. As he points out, "all the successful sciences and arts are of humble origin—all begin with the cautious development of lowly skills until the point of logical and experimental expansion is clearly gained.

The second step is accurate observation of things and events; selection, guided by judgment born of familiarity and experience, of the salient and recurrent phenomena, followed by classification and methodical exploitation. The third step is the judicious construction of a theory—not a philosophic theory, nor a grand effort of the imagination, nor a quasi-religious dogma, but a modest pedestrian affair—a useful walking stick to help on the way." He sums up by saying that the practitioner of any art must have (1) an intimate firsthand familiarity with that which he practices, (2) systematic knowledge, and (3) an effective way of thinking.

The most elementary and most important of the social skills is the ability to facilitate complete factual and emotional communication. Mayo defines it as the capacity to encourage and "to receive communications from others, and to respond to the attitudes and ideas of others in such fashion as to promote congenial participation in a common task."

Bulletins, employees' newspapers, and annual reports to employees can play their part in the establishment of communication by informing the organization as to objectives, policies, the reasons for changes, and the results achieved, but, as Keith Powlison of Armstrong Cork points out, management sometimes makes its pronouncements suspect by unwarranted protestations of virtue. For example, some reports to employees show the total wages and salaries paid in contrast to the dividends paid, which is all right, provided it is not a direct or indirect implication that the ratio is an indication of the extent to which the workers are voluntarily and purposefully treated better than stockholders. Even at best, however, printed information of any kind cannot do very much. To fulfill its responsibility management must, at all levels, give great importance to both oral and written communications between

groups and otherwise do everything in its power to promote congenial participation of one group with another.

I was recently told of a situation in a medium-sized company where long negotiations on a wage increase had resulted in an impassé and a probable strike. Finally, as a last resort, the head of the company appeared before the union negotiating committee and described to its members the situation of the company—its commitments, its costs, prices, and predicted deliveries, and profits. Neither the president nor any other top official had done this before. The union asked for 24 hours to consider the president's statements and came back with an offer that the company could live with.

Organization charts and accurate definitions of responsibility are essential both to communication and to teamwork. No man, be he supervisor or worker, can do his best unless he knows what he is responsible for, to whom he is responsible, how he is to be judged, and his relations to others with whom he must work. However, the old concept that responsibility and authority are delegated downward from the top executives to the various departments, divisions, and subdivisions is of questionable validity. This concept carries the implicit assumption that the senior is capable of doing the work of his juniors; for example, that a chief executive whose training has been that of a lawyer can "delegate" responsibility for an extremely complex electronic research. Is it not more logical to adopt Harry Hopf's concept that "responsibility is inherent in function," and is therefore assigned rather than delegated?

As Chester Barnard says, "The business of the manager is to facilitate a balanced relation between various parts of the organization, so that the avowed purpose for which the whole exists may be conveniently and continuously fulfilled. If he is not successful in this, he will have no actual authority in the organization—however important may be his title." An approximate definition of "authority" which he gives is that it "is the character of a communication (order) in a formal organization by virtue of which it is accepted by a contributor or 'member' of the organization, as governing the action he contributes—under this definition, the decision as to whether an order has authority or not lies with the persons to whom it is addressed, and does not reside in 'persons of authority' or those who issue these orders. . . . Thus authority depends upon a cooperative personal attitude of individuals on the one hand, and the system of communication in the organization on the other."

An important social responsibility of management is the morale of the group whom it is directing. LeRoy Kurtz defines "morale" as faith in and enthusiasm for the organization, its leadership, its objectives, the achievement of those objectives. Would it not be logical to assign functions so completely and to provide sufficient assistance to all supervisory personnel to permit them to devote a considerable part of their time to receiving and responding to communications from the members of their group, and the cultivation of the morale of their group?

Those who have developed a high degree of social skill in encouraging and receiving communication give many examples of the great importance of nonfinancial incentives. Avery Raube has written an interesting article on this subject in the December, 1946, issue of the "Record" of the National Industrial Conference Board. He reminds us that most of us have at one time or another chosen our jobs because we were interested in them, and not because of financial reward. He also points out the importance to all of us of knowing the objectives of our group, what is required of us in achieving those objectives, and what progress is being made toward the attainment of the objectives. He underlines the inhibiting effect of fear and the stimulating effect of approval and encouragement. He emphasizes the fact that nonfinancial incentives are often more important than financial, and that they cannot be sold except by putting them into practice.

I happen to be on the boards of two colleges and have worked closely with two others. The members of the faculties include some of the most eminent people in the United States. Their salaries are all low, and I know that many of them have been offered several times as much by industry. They prefer the college because they are interested and feel that they have a mission. It is the same with the other ministries—the doctors, the nurses, the men of religion. One of the most able businessmen I know is a Mennonite clergyman; he has made millions for the people of his community by reviving its principal manufacturing industry but accepts little for himself.

Although many experienced observers have recently presented a great deal of apparently irrefutable evidence that we are in a state of unstable social equilibrium and headed toward social chaos—internationally by reason of ideological antagonisms, nationally by reason of group antagonisms, industrially by reason of our lack of social skill—and are even in danger of the destruction of the family as the basic social unit by reason of the rapidly rising divorce rate, it seems to me that there is a good deal of justification for taking the optimistic view that we are developing social skills fast enough to arrest these trends.

TRENDS TOWARD DEVELOPMENT OF SOCIAL SKILLS

One of the most encouraging indications is the very pronounced trend of big industry toward decentralization of both management and plant into small units in small communities. Don Mitchell, president of Sylvania, points out that of all the criticisms directed at big business, only one is valid, and that is, that it reduces the individual to an automaton. He describes what his own company has done to remove this objection by decentralizing the industry into twenty-three autonomous plants and five laboratories. The average size of these plants and laboratories is less than 500 employees, and all of them are located in small communities. Thus it is possible to develop a high degree of social solidarity. The same trend is being followed by many other organizations, among them being Johnson & Johnson, the du Pont Company, the General Electric Company, Westinghouse Electric Corporation, The General Motors Company, the American Home Products Company, and International Harvester.

Another cause I find for encouragement is the attitude of the young men who are taking graduate courses in business administration at Harvard and at the Massachusetts Institute of Technology. I have talked to a great many of them and, without exception, they are all fully aware of the great importance of social skill in administration. Many of them propose to get jobs at the working level and in that way learn how people feel and think, thus developing their understanding of people and their own ability to aid people in adapting themselves to their jobs and to other people.

Perhaps most encouraging of all is the trend toward the appointment of relatively young chief executives and the enlightened social attitude of many of these executives. Some of the outstanding men that I have in mind are Henry Ford 2nd, president of Ford Motor Company; Charles Luckman, president of Lever Bros.; and Don Mitchell, president of Sylvania. The speeches and published statements of all of these young men set a pattern which, if followed generally, would leave little doubt as to our ability to develop a successful adaptive industrial society.

Charles Luckman, in a recent talk before a Harvard group, summarized the purely material considerations which we usually take into account when selecting the location for a new plant; considerations such as accessibility to raw materials and

(*Continued on page 584*)

A Development Center for FOREST-FIRE-CONTROL EQUIPMENT

By IRA C. FUNK

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BETTER tools with which to fight forest fires have been the constant need of all forest-protection agencies. In the early days, the forest ranger and his small group of volunteer fire fighters were dependent upon their own ingenuity in developing tools and equipment which might be better than the old-fashioned axe and shovel. Later certain individuals with mechanical inclination, but without the aid of trained mechanical engineers, were somewhat successful in mechanizing forest-fire-control equipment. Until recently, a large portion of forest-fire-control-equipment development work has been carried on in a "backyard experimentation" manner, under limited conditions, and without adequate controls. Naturally, this has led to duplication of effort, indefinite conclusions, and poor reporting.

The rapid development of military equipment during World War II brought to the attention of all forest-protection agencies the great possibilities that a real development program of fire-fighting equipment would have in forest-fire control. During 1944, by direction of the Chief of the Forest Service, a thorough survey was made throughout the State, private, and Federal forest-protection agencies and industry, to obtain ideas and opinions of fire fighters, equipment specialists, and administrators regarding the needs of the services in development of forest-fire-control equipment. This was followed in January, 1945, by a service-wide conference held for the purpose of reviewing the fire-equipment-development situation and preparing a plan of action. Among the several proposals resulting from this conference was the proposal to establish four fire-control-equipment development centers; one at Portland, Ore., serving the Pacific Northwest; one at Arcadia, Calif., serving the Pacific Southwest; one at Roscommon, Mich., in co-operation with the State Experiment Station, and serving the Lake states; and one in the Southeast. The development centers at Roscommon and Portland have been in operation for some time, and the Arcadia center since early in 1946. The development center for the southeastern United States has not as yet been established.

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U. S. Forest Service Photo

TEST OPERATIONS OF HELICOPTER IN MOUNTAINOUS AREAS

Some of the general policies governing these fire-control-equipment development centers are as follows:

Existing facilities of the Forest Service, states, universities, and industrial concerns are to be used to the maximum extent. Permanently assigned personnel are to be held at the lowest possible number and additional specialists and other personnel are to be temporarily assigned as needed for specific projects. The development of forest-fire control equipment is to be promoted to the greatest possible extent through co-operation with all forest-protection agencies and interested private industrial concerns and individuals.

The development center at Arcadia, Calif., may serve as an example for more detailed discussion. The offices of this center are located in conjunction with the Forest Service regional fire-equipment warehouses and automotive and engineer equipment-maintenance shops, approximately 15 miles east of Los Angeles. The present permanent personnel of the center consists of one senior mechanical engineer, one associate mechanical engineer, one mechanical engineering aide and draftsman, and one stenographer. The number of temporary personnel assigned for various projects during the last year has varied from 5 to 25 individuals. Some of the more interesting service-wide projects included in the development program at this center are the following:

HELICOPTER OPERATION IN MOUNTAINOUS AREAS

It is easy to imagine the advantages of a hovering type aircraft in transporting fire fighters and equipment to forest fires in areas now accessible only by long pack trails or by parachute from conventional aircraft. In some of these areas which are extremely high-valued watershed lands, the cost of an adequate truck trail system for fire protection is prohibitive. Considering the popular claims for the helicopter, many fire-control managers hope that soon the answer to many of their prayers will be received. Thus, with much enthusiasm, information on helicopter operation in mountainous areas was requested in 1945 from designers, manufacturers, and the Army Air Forces. At that time, however, none were able to give definite information on load-carrying capacities, land-

U. S. Forest Service Photo

TEST OF ARMY CARGO CARRIER M29 (WEASEL) IN STEEP BRUSH-COVERED TERRAIN

ing-area requirements, landing and take-off techniques and flight paths, rates of climb, and hovering characteristics for altitudes above the hovering ceiling without ground effect. In order to obtain the needed information firsthand and at the earliest possible date, a series of tests were planned in co-operation with the Air Rescue Service, U. S. Army Air Forces.

The purpose of these tests was to determine by actual flight and by simplified field procedure and measurements the information necessary to establish the pay-load capacities and performance of the latest Army-type helicopter when operating in mountainous areas up to elevations of 10,000 ft above sea level; furthermore, to determine the usefulness of the helicopter in various air rescue and Forest Service activities. It was not the purpose of these tests to make a scientific study of the principle of helicopter flight, nor an elaborate engineering design study of the helicopters tested. Approximately 150 hours of test flying were conducted at six different landing spots ranging in elevation from 90 to 6850 ft above sea level. Converting these elevations to N.A.C.A. standard air conditions increases this range from 90 to 9200 ft above sea level.

When the tests were concluded in October, 1946, definite safe-load limits and landing-spot requirements had been established, as well as the development of landing and take-off techniques for the altitude range noted in the previous paragraph. The usefulness and limitations of the helicopter in air rescue and in transporting fire fighters and equipment to fires had been demonstrated.

The results of these tests indicate that helicopters now under current production will barely meet Forest Service requirements. Some of the needed improvements are: An increase in hovering ceiling; increase in useful load; and improvement in stability of the craft so as to reduce pilot fatigue. In view of current developments, it seems that it is reasonable to expect that helicopters fully meeting requirements will be in production within another year.

SPRAY-NOZZLE STUDIES

Although some forest-protection agencies have used so-called "fog nozzles" for some time, the introduction of the question of the relative merits of straight stream, sprays, low-pressure fog, and high-pressure fog has caused many a heated argument between forest-fire-control men. There appears to be no question about the superiority of fine spray when used with proper technique on fires in enclosed compartments or on highly inflammable liquid fuels. The justification for spending 10 to 20 times as much for a fancy fog nozzle as for the ordinary high-quality garden-hose nozzle has been questioned, however, where it is to be used in forest-fire control. In suppressing forest fires it is desirable to use equipment of the lightest possible weight with techniques that will consume a minimum amount of water.

As an initial step to definitely determine which of the currently produced spray and fog nozzles are most effective when used in combination with existing pumper-tanker equipment, a series of tests is being conducted co-operatively with the University of California at Los Angeles. These tests include determining discharge rates, efficiencies, outline of spray pattern, and water distribution within the spray pattern for 11 currently manufactured fog and combination fire nozzles.

The second phase of this study will be to determine the relative effectiveness of the spray produced by these nozzles on fires in several forest fuels under different controlled conditions.

TESTS OF MILITARY AND COMMERCIAL-TYPE VEHICLES

Speed on mountain highways and one-way truck trails with grades up to 10 per cent and hill-climbing and cross-country performance are as important factors in fire-control vehicles as their load-carrying capacity. Early pumper tankers were often designed to carry every drop of water that the structural design of the vehicle would allow. This was usually done with a considerable sacrifice in speed on mountain grades and in other performance. The introduction of all-wheel-drive vehicles into fire-suppression work during World War II further emphasized the need for establishing load limits for fire vehicles based upon performance.

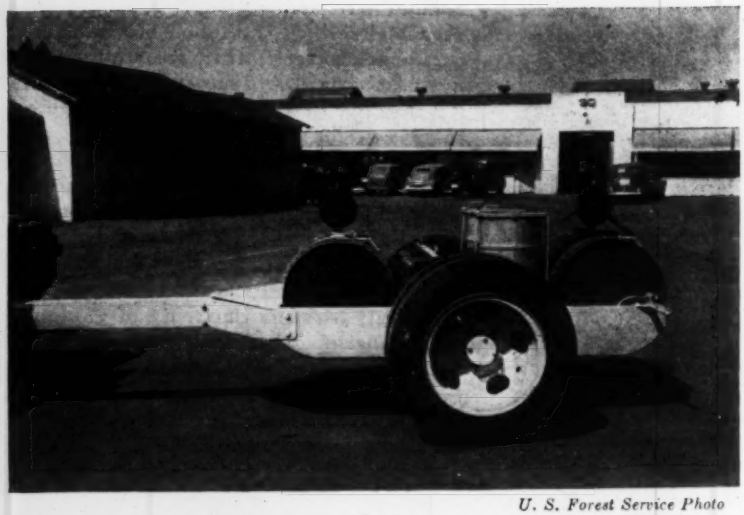
In order to determine the effect of loading on vehicle performance representative test routes were selected and a cross-country and hill-climbing proving ground was constructed on the Angeles National Forest. Carefully controlled tests have been completed on several rear-wheel- and all-wheel-drive vehicles of comparative types and capacities.

Results of these tests have indicated that all-wheel-drive chassis are superior to rear-wheel-drive units when traction is the important factor. This is of course true in cross country and hill climbing. Front-wheel drive has only a small advantage on roads during dry weather when fire hazard is greatest. Auxiliary transmissions have many advantages both on mountain roads and in cross-country work. Loading to structural limitations had little effect on hill-climbing performance of all-wheel-drive vehicles. However, considerable speed on paved mountain highways is lost by loading vehicles to these limits.

It is expected that future tests on vehicles might be considerably simplified by the use of a more suitable truck dynamometer. Such dynamometers, used to date, have not been of sufficient torque capacity to permit the proper application of data obtained in this manner.

TRACTOR TANKER

Although tractor-bulldozers have been used in forest-fire control for many years, the need for a fast crawler vehicle equipped with water tank, pump, and hose, has not as yet been filled. Experiments with production-model crawler tractors have been unsuccessful in that they were too heavy and too slow, or if light, were too slow and had insufficient power for hill climbing. Also, the production model of crawler tractors does not lend itself to carrying a load since it is primarily designed to push or pull one.



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UTILITY, FUEL, AND LUBRICANT SERVICE TRAILER FOR CRAWLER TRACTORS

As a result of a survey of the special crawler-type vehicles developed during the war, the cargo carrier, M-29, commonly known as the "Weasel," was selected for further experimentation in the development of a tractor tanker. Special proving-ground and road tests have been completed in order to determine performance of this vehicle with different loading and one Weasel is now being equipped with water tank, pump, etc., for tests on actual fires this summer. Results of performance tests show that the Weasel has nearly all of the desired performance for forest-fire purposes. That is, in addition to being able to travel mountain roads with the same load and at the same speed of a $^1/_2$-ton pickup, it can travel contouring on side slopes and climb hills up to 60 per cent. It has several mechanical and structural deficiencies, however. Improvement in brakes, drive sprockets, and frame are needed. Since the Weasel is no longer in production, it cannot be expected that modified Weasels will fill the needs. We do hope, however, to learn from these tests what performance is required in an effective crawler-type fire vehicle and how that vehicle might be constructed.

UTILITY AND SERVICE TRAILER FOR CRAWLER TRACTORS

In the western regions, as many as five crawler tractors of the D-6 and D-7 size are in use at the same time on some fires. The need for lubrication and fuel service for these tractors without requiring them to leave the fire line calls for a trailer unit that can be drawn by another tractor over logs, stumps, ditches, and boulders to the tractors to be serviced. Meeting this need included simply the design and construction of a single-axle dual-wheeled underslung trailer with a steel "stone boat" frame and bed. This unit served satisfactorily on fires last season and with minor modification its utility for other than fuel and lube service can be considerably increased. In fact, when equipped with water tank, pump, and hose, it may partially fill the need for the tractor tanker.

COMPARATIVE PERFORMANCE OF D-6 AND D-7-SIZE TRACTOR-DOZER

Many arguments have occurred between fire-control men on the relative abilities of crawler tractors of different weight and power, on cable and hydraulic dozers, and on straight versus angle blades. In forest-fire service, the tractor-dozer must be transported to the fire as quickly as possible. Faced with the problem of replacing many worn-out and obsolete tractors and with state-highway limitations on tractor transports, a test site was carefully selected and a series of tests were performed to determine under what conditions the smaller tractor could be substituted for the larger, as fire-fighting units. Comparative tests were also made with straight and angled dozer blades.

Results of these tests can be briefly summarized as follows: The D-6-size tractor more nearly meets state requirements with existing transport. Approximately one minute per mile is gained in transporting the D-6 over the D-7. The rate of fire-line construction of the D-7, as may be expected, is greater than for the D-6. However, in many instances when the unit is to be transported over 20 miles to a fire, the average amount of fire line to be constructed can be completed as soon with the D-6 as it could be with the D-7.

The angle dozer is definitely superior to the straight blade, and the rate of fire-line construction when operated downhill is so much greater than the rate when operated uphill, regardless of slope, that wherever possible time can be saved by walking the tractor to the top and constructing the line downhill.

SPECIFICATIONS FOR FIRE EQUIPMENT

Since 1937 the Forest Service has maintained a file of specifications covering fire equipment used in more than one Forest Service region. Especially during the war years, little was done to keep these specifications up to date. They are now being completely rewritten and it is the intention of the Service to keep these specifications up to date currently. Except when necessary from the viewpoint of standardization, detailed requirements covering materials and dimensions are to be eliminated. This can be done only by devising service tests and requirements that can be accomplished by field personnel in so far as possible without elaborate testing facilities. The revision of specifications of certain types of fire equipment and the planning of testing procedures and equipment is a continuous assignment for each development center.

REGIONAL PROJECTS

In addition to the service-wide projects which have been described, the Arcadia development center conducts the development of forest-fire-control equipment having an application more or less limited to the California region. Some of the more interesting projects currently conducted in this category are the following.

DESIGN OF A 300-GALLON 5-MAN PUMPER TANKER

Since vehicles upon which fire equipment is permanently mounted rarely run over 10,000 miles in ten years and therefore become obsolete long before they are worn out, it is the policy of many Forest Service regions to construct their tanker pumper in such a manner that the fire equipment may be easily changed from one chassis to another. By doing this, fire equipment will generally be on relatively new chassis, and the chassis from which the equipment is removed may be worn out on other projects before it becomes obsolete. Since chassis must be purchased through bid procedure and each truck manufacturer builds comparable models with different frame widths and lengths behind the cab, it is not an easy problem to draw up an equipment layout to include 300-gal tank, pump and engine, live hose reels and hose baskets, seats for three men, and boxes and cabinets for a multitude of accessories and tools, that will meet the requirements of the fire fighter, have proper load distribution, and be changeable from one make of truck to another by merely unfastening and refastening the frame U-bolts.

This, however, is being done and it is expected that before the

coming fire season is well under way nine of these new tanker pumpers mounted on cab-over-engine, all-wheel drive chassis, will be in the field in the California region. In addition, an experimental unit is planned. This unit is to be an all-aluminum-alloy job with new experimental pumps and greater water-carrying capacity. On the experimental unit, new ideas and equipment will be tried so that when the time comes to modernize designs for production purposes, it can be done quickly and include the latest proved ideas and equipment.

DESIGN OF SLIP-ON PUMPER-TANKER UNITS

In order to make full use of ½-ton pickups and jeeps used in fire patrol during the fire season and make possible their full use for other activities during the other months of the year, a small water tank, pump, and hose unit is being designed in co-operation with industrial concerns that have further market for such an item. This unit will consist of a small lightweight portable pump with gasoline-engine drive, 75 to 100-gal aluminum tank, and necessary hose and fittings. The complete unit is to be assembled on a skid arrangement with suitable fastenings so that it may be placed in a ½-ton pickup or jeep by merely sliding the unit into the vehicle and connecting the fastenings. It is expected that approximately 30 of these units will be placed in service in the California region during the current year.

POWER FLAME THROWER

After a fire line has been constructed in heavy fuels, especially brush stands, it is necessary to burn out the fuel between the fire line and the fire. Fires are also sometimes stopped by back firing from an existing road, trail, or newly constructed fire line. In order to do this satisfactorily and efficiently, a power flame thrower was designed several years ago in the California region. This unit consisted of very lightweight pump and gasoline engine, fuel supply tank, fuel hose, and flame-thrower nozzle. The original unit demonstrated the value of such a device but was mechanically unsatisfactory in that it was too small and of too light construction. Present development on this equipment has been taken up by a western industrial concern and the Development Center's part on this project is at present limited to offering of suggestions and to the testing of the equipment produced by the concern.

In addition to the regional projects already mentioned, one of the regular functions of the Development Center personnel is to take part in the suppression of forest fires and to observe the employment and operation of fire-fighting equipment on such fires. Last season, approximately 30 per cent of the time of the Center's technical personnel was spent on forest fires.

Miscellaneous operation and maintenance problems concerning fire equipment also consume considerable time of Development Center personnel.

REPORTS AND PUBLICATIONS

Obviously, little can be gained by centralizing experimental work on fire-control equipment unless the knowledge gained is currently distributed through the medium of reports and articles for publication. In addition to periodic progress reports on all development work, reports are prepared for publication as a numbered Forest Service Equipment Development Report or as an article for publication in *Fire Control Notes*, which is published quarterly by the Forest Service. *Fire Control Notes* and Forest Service Equipment Development Reports are sent to all forest-protection agencies.

For certain projects, such as the helicopter project already mentioned, due to their technical and specialized nature, special reports are prepared for limited distribution. Except in special technical reports, detailed discussion of testing procedures, instruments, and controls are usually omitted although a complete record of such details is kept in the Development Center files and can be furnished to interested individuals upon request.

Besides the project work being carried on at each Development Center, all personnel in fire control habitually search for new ideas applicable to the various phases of their work. Trade and professional periodicals and other publications are continually gleaned for things that might even remotely have some effect on equipment development. Close contact must be maintained with all interested industries and with fire-fighting personnel and fire-equipment men of all forest-fire-protection agencies.

A few of the projects to be started in the near future include: (1) An over-all investigation of use of water, wetting agents, and other chemical additives to water, in suppressing forest fires. This project will involve three phases: laboratory tests, controlled field tests, and field application. Development of fundamentals and techniques for measuring the many complex factors will be important problems. (2) The development of a rocket projector or mortar for the purpose of throwing fire-extinguishing materials several hundred yards onto inaccessible fires. (3) The modernization of feeding methods and equipment used in preparing food for fire fighters.

It must be realized that the fire-control-equipment development-center idea is still quite new with the Forest Service and the center at Arcadia is just getting well started. It is hoped that as these centers increase their circle of co-operators, including members of The American Society of Mechanical Engineers, a real program of development of forest-fire-control equipment will be realized.

U. S. Forest Service Photo.

TRACTOR-DOZER TESTS D-6 CATERPILLAR HILL CLIMB THROUGH HEAVY BRUSH

Developing the YOUNG ENGINEER

By A. C. MONTEITH

WESTINGHOUSE ELECTRIC CORPORATION, EAST PITTSBURGH, PA. MEMBER A.S.M.E.

YOUTH is the backbone of a progressive organization; as a matter of fact, it represents the whole future of an organization. Men recruited today become the managers of tomorrow. Youth should have no doubts about the possible opportunities in management. One of the greatest needs at the moment and for the future is the securing of adequate man power with management qualifications. One doesn't go out and hire a manager when an opening occurs, but, by a thorough grounding in company policies and methods of operation, he is trained over the years to fill positions of increasing responsibility. There is no greater satisfaction than watching the progressive development of a young man in an organization. How can we assure him of every opportunity to move forward?

TECHNICAL GRADUATES IN DEMAND

Today, the technical graduate is a much-discussed and much-sought-after individual, and, unless management is careful, he will acquire a misconception of his importance to industry. However, the fact that the technical graduate is sought after and that we talk freely of a lack of engineers emphasizes the need for management to do everything possible to present a clear and concise picture of its expectations when these technical graduates enter a chosen field. To succeed requires entering a position with enthusiasm, which can come only from a full knowledge and understanding of what is ahead, both in work and in opportunity. Management should do everything possible to help the young man develop the proper perspective so that he will be anxious to perform any work given to him that will help him grow into his job. He should not be allowed the idea that possible momentary emphasis of his importance will assure him of a successful career regardless of how he applies himself.

In hiring young men, management should select only those who have the necessary qualifications to run some job someday. Mr. Lamme, who was chief engineer of Westinghouse for many years and who took a very keen interest in young men, used to counsel our people that, while he recognized that it took both leaders and average men to run an organization, only those who they felt would someday be top men should be hired, and the organization would, out of this selection, finally attain a balance.

No attempt will be made to review the desirable college curriculum for young men, other than to say that it should be designed to give a good foundation, heavily reinforced with fundamentals. Fundamentals are stressed because the opportunities in our country today are so varied, and the branches of a field are so many, that a young man must strive to know everything about something, rather than something about everything. Because of the complexity of the problem, industry has an obligation to work with educational institutions to help them prepare curricula that will give the graduate the best preparation for the time when he approaches the starting phase in his career. But assuming that a man has all the fundamentals and has passed all the requirements of good personality, scholastic achievement, demonstration of leadership in his class, etc., what then should be our program? We should make known our expectations in a general way and promote an understanding of our way of working.

Presented at the Pittsburgh Mechanical Engineering Conference, Pittsburgh, Pa., April 22, 1947.

SELECTION OF MANAGEMENT CANDIDATES

A man must of course have some inherent characteristics that fit him for management, he must have the knowledge of his company's policies, organization, and products, and he must above all be given an opportunity to develop his capabilities. This can be summarized in the statement, "Managers are born and made, not just made."

Then what are a few of the characteristics of an individual with good management possibilities; how can we provide him with tools to work with; and how can supervisors help develop the possibilities in him?

If we are not to overlook someone, we must in the initial stages work with all, before the potential managers can be recognized and developed. In this process of working with all, we will find some who do not have the temperament nor the desire to become managers. Their goal is to become outstanding technical authorities. These individuals are an important part of an organization whose product is dependent upon technical development and achievement. They should have just as much encouragement as those who will go into management channels, and many of the following comments may have some application to their case.

FUNDAMENTAL CHARACTERISTICS FOR MANAGEMENT WORK

A few characteristics which should be inherent in a young man if he is to progress in management follow:

1 He should have his mind fixed on a definite field of endeavor but should allow some flexibility in his thinking. In other words, he should keep his thoughts adjusted to accept opportunities, regardless of location, if they appear to give added responsibility in his field.

2 He should be loyal to the company for which he works. This does not mean blind loyalty. He should express himself on any points of mutual interest, but once a decision is reached on the policies or procedures, he should accept them, even if they are contrary to his thinking. He should realize that a capable management analyzes every adversity. If there are too many drawbacks to a policy it will be changed, and some of his ideas may have a chance for adoption.

3 He must realize early in his career that interest in his job is paramount. One lives but once and therefore must obtain the maximum of satisfaction from his daily work. Lack of interest causes the loss of more opportunities than lack of knowledge.

4 He should be willing to work. Not just the performance of assigned tasks, but extra effort to improve and broaden himself through outside reading, further study, and supporting his profession by attending and taking an active part in its association meetings.

5 He should be encouraged to be a team player. The ability to get along with people in our complex civilization is vital. With a given job, there should be encouragement to approach more experienced people to obtain guidance. Emphasis should be placed on getting the job done, rather than on doing the job personally. The opinions of others often provide

the key to accomplishment of a task, and full credit must be given to them. Individual credit is achieved by getting the job done. The man should realize at all times that he is selling his company and his product and this is accomplished most fully when he sells himself completely.

6 He should have determination. From time to time criticism will be aimed at him by his fellow workers. He will have to develop the art of ignoring some of this, especially if it stems from petty jealousy. A career is not easy if progress is attained at a maximum rate.

7 He must expect that his mistakes will be noted. He should, however, realize that managenent recognizes fully the old adage, "He who never makes a mistake never does anything." With the proper attitude on the part of management and the individual, analysis of honest mistakes will show a profit, but repetition of honest mistakes denotes carelessness, a lack of understanding of the job, or interest in it.

8 He must be encouraged continually to analyze himself on all matters, but especially to be sure he understands his objectives. Consultation with a trained supervisor is often helpful. The young man will be more productive if his objectives are always clearly projected. The supervisor is there to assist him, and he should be encouraged to look to the supervisor for guidance.

9 He should be encouraged to accept responsibility. It is always a pleasure to observe a man take a job, line it up, ask intelligent questions regarding the problem and objectives, and come back with the answer.

10 He should be encouraged to be a businessman in a business organization, acting like a mature person, and above all being natural.

These points of course do not cover all the desirable traits but are sufficient to suggest that, in general, progress will be made if a reasonable degree of common sense is mixed with initiative.

TRAINING YOUNG MEN IN RESPONSIBILITY TO THE ORGANIZATION

From experience of the author's company in training young men, it is evident that early in his career, the individual should be thoroughly informed on the policies, operation, and organization of the company for which he works. Being acquainted with the opportunities offered by a company makes it easier to select a branch in which he will be happy and into which he will fit. In general, we allow about one year of training before placement in a final assignment. This includes a basic training period, consisting of orientation, production assignments, test-floor assignments, and product conferences. This training is given to all students, whether they are to be salesmen, engineers, or manufacturing-department employees, and whether they are mechanicals, electricals, or graduates of some other branch of engineering. During the basic training period the trainee is given the benefit of counsel in his work and is graded on all that he does. As a result, he learns to know the organization and the organization to know him, so that at the time of segregation to sales, engineering, or manufacturing, there is reasonable assurance that he will be content with his job. We are satisfied that he has chosen the field in which he should make the greatest progress. This processing is what we call segregation and is followed by specialized training.

Before covering the specialized training, let us review some of the things given in the more general basic training.

Orientation consists of a period of about one week during which the graduate locates living quarters and becomes acquainted with the organization. Some classwork is given, primarily to acquaint the student broadly with the corporation, its facilities, and its products, but more specifically to acquaint him with the training personnel who are to guide and counsel him in case of need, and to know to whom he must look for answers to questions which may arise. By treating the students as individuals, they do not become lost and confused. The student is given a chart showing the personnel of the training organization, where they are located, how to reach them, and their respective responsibilities.

The production assignments are of one month's duration and are designed to give the student firsthand knowledge of the works organization by bringing him into direct contact with the flow of an order through the shop. He is given a work-assignment manual at the time of starting, which outlines the complete shop organization and identifies that part of the organization with which he will be associated. Before being given another assignment, he is questioned to see what knowledge of the first he has acquired and whether he was treated with consideration by the organization. At the same time, his immediate supervisor presents a written report giving his reactions to the man and indicating whether he would hire him, and if not, why not.

The test-floor assignments are six weeks to two months in duration. These assignments are given so that the young man can observe how commercial equipment is built and what is expected of it. Here he comes in contact with the designers and is given the job of working up test data into final form for the engineering department.

The product conferences, lasting eight weeks, give him insight into the corporation, its products, and its personnel. Here he gets the engineering background of the major products by lectures and guided study. He is graded on his oral presentations and is given an examination to determine his grasp of each subject. These are technical classes definitely at the graduate level, held full time for an extended period, and led by recognized experts in each field covered. While the work is planned during regular working hours, assignments are of a nature which require outside study. Thus the student has an opportunity to apply his formal education toward an understanding of the latest design, development, and application. Here again, he is in daily contact with responsible experienced personnel with whom he can counsel concerning his studies and his future. To the training staff the opportunity is provided to establish a comparative rating of technical background, ability, and resourcefulness among the student group.

When the student has successfully participated in the assignments and classwork described, he will have concluded the prescribed basic-training program and is then ready to undertake additional temporary assignments, but of a more specialized nature, and only in the field in which he will find permanent placement. In other words, he is categorized, and this is the meaning of the word "segregation." This function is delayed until completion of the basic-training program so that the association with each man during training can be used to advantage. The various mental, physical, and personal traits, ambitions, and special abilities can be observed during the first several months of training, and hence the decision (both by training personnel and the student himself) as to preference of occupation will be well-founded. It is of great advantage both to the student and to the sponsoring company to delay specialization until the company and the engineer are mutually well acquainted. Many errors in the application of particular developed abilities and native ingenuity are thus avoided.

The last portion of the student's formal program is that of training for placement in his chosen field; usually engineering (viz., research, development, design, and application), sales, or manufacturing activities. In each work assignment during this specialized training, the individual is a candidate for placement, and both he and the local management have this in

mind as his tasks are undertaken. As during basic training, students are counseled before and after each assignment, reports being submitted by each supervisor. This information is used as a guide in determining the nature of further assignments and also for final placement.

SPECIALIZED TRAINING

Each student receives classroom instruction during his specialized training. For those segregated to sales work, a concentrated sales-engineering class is operated where equipment application, sales technique, company policies, etc., are taught. For manufacturing students a class is held which involves time study, manufacturing engineering, methods engineering, plant layout, quality control, and industrial relations. Similarly, for those definitely pointed toward engineering placement, a class program on engineering principles and procedures is afforded. These schools serve to prepare the student more adequately for his placement and to make him a productive technical employee as quickly as possible. A multitude of methods and techniques are thus taught collectively which anticipate hundreds of questions that otherwise must be answered individually after placement. The lost time and inefficiency thus prevented would be difficult to estimate.

For certain engineering students who display unusual ability in the purely technical fields, two schools are provided, namely, the electrical-design school and the mechanical-design school. Outstanding technical students are selected for these schools by competitive examination after careful counseling. Each school embraces several courses in advanced fundamentals, definitely at the graduate level, which are designed specifically to tutor outstanding students in development and design techniques. It is the intent that, through the use of expert instructors leading small classes, each student will receive individual attention, and his creative ability can be fostered in whatever line he shows talent. Satisfactory participation in this work requires a large amount of study at night as well as full-time effort in class during the regular working day. Credits affording a good start toward advanced degrees are given for successful completion of these schools.

When the graduate student accepts a position in any one of the many technical departments of the company, his formal training is of course concluded. It would be shortsighted not to encourage further technical and business education, so a program of graduate study, arranged for maximum convenience and minimum expense, is provided at all locations where a sufficient concentration of technical talent exists. Hundreds of men, through participation in this program, have been granted advanced degrees from the co-operating universities. Courses are designed to provide the specialized education which the young engineer is now ready to accept. He has his fundamentals from undergraduate work, and his period of observation during industrial training to channelize his abilities, so now he can undertake specialized techniques with some confidence that his studies are correctly designed to develop his ingenuity to best advantage.

Some might say that a company hiring relatively few technical students cannot afford such a program. The author's company believes that a training program can be designed for any concern, large or small. Naturally, the smaller company cannot afford an extensive organization to guide the training program. However, if only one man a year were recruited, he could at least be assigned to an experienced man who would have organized his thoughts on the background and policies of the company and impart them to the young man. He could further design a series of assignments with different individuals which would give the young man an insight into the various branches of the business.

PERMANENT PLACEMENT

The student is now ready for permanent placement. He has the proper characteristics and has received comprehensive training which fits him for his chosen job. One other function of the training personnel which continues after placement is to make a periodic check on the progress of young engineers for two or three years. These training experts know the men well, and through broad contact with all the divisions of the large organization, are in an ideal position to suggest remedies if cases of misplacement occur.

From this point on it is up to the man himself whether he succeeds or fails, and also to some extent to his supervisor whether he progresses into a management position. The supervisor has a real responsibility in developing men. It should be part of every supervisor's job. He should work at it faithfully, or the proper results will not be achieved. If the man is to progress rapidly, the supervisor must pass responsibility to him at a rate which allows him to keep his head above water, but only with some struggle. The greatest difficulty a good man will encounter is to convince the supervisor, who has helped him to develop, that he should be allowed to move to another post for faster advancement. It is a trait of human nature to try to hoard gems.

The supervisor should never stand in the way of a man's progress. That does not mean that he should let other departments raid him for good men, but he should analyze every offer made to his men and if one presents a greater opportunity than he has to offer or can immediately foresee, he should have the courage to allow the man to consider the job. The young man is encouraged and has the greatest opportunity for advancement if every supervisor will permit him to have a chance at any job that will offer a definite advancement in responsibility.

THE SUPERVISOR'S RESPONSIBILITY

The supervisor has an even greater responsibility in consulting with a man who does not measure up to the job. He may be a misfit. If placed in another type of job, he might do excellent work and therefore will have a better opportunity for advancement. The supervisor should assist him to become located to the best advantage. This broad principle is advantageous to the individual and to the company. The supervisor should have confidence in the ability of every man who works for him.

There must at all times be mutual trust and respect between the young man and the supervisor.

The greatest restraint on the part of the supervisor is needed when mistakes are made. Management must recognize that some honest mistakes will be made and that they must be used to the ultimate advantage of the individual and of the company at all times. "We learn by our mistakes," can apply a few times in everyone's career.

One of the early responsibilities of management is to inspire the young graduate, and at the same time to make him fully aware of the fact that a college degree is not a complete education, but a forerunner of much more to be accomplished before a full contribution to society can be made. At the time of entering industry, the principal change is that he has gained sufficient knowledge to start earning while learning. Management should help the young man to take further courses of study on subjects of mutual interest both to the young graduate and to the company. This might be in the form of classes conducted by the company, by local universities, or by company-university combinations. The author does not know to whom should go credit for the statement, "Education is a journey, not a destination," but it is a simple one which summarizes a lot for the young graduate.

CENTRIFUGAL CASTING

Process Applied to Stainless- and Carbon-Steel Tubes

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CENTRIFUGAL casting of metal has been a routine production technique in this country for more than 25 years. Prior to 1942 this method was confined largely to the manufacture of cast-iron pressure pipe in sand-lined molds and in metal molds. The process has amply demonstrated its economic soundness and has resulted in a product vastly improved over the antedated pit-cast pipe.

The advent of war created demands for much material which could not be satisfied through the usual supply channels. These exigencies accelerated research toward the end that suitable facilities might be utilized to overcome these deficiencies. A critical shortage existed in that period for forgings and for rolled steel tubes of almost every description. It was a natural progression to attempt production of centrifugally cast steel tubes in pipe-making equipment. This paper is concerned with problems encountered and results achieved in the production of relatively heavy-wall, centrifugally cast, steel tubes.

By this we mean tubes having wall thicknesses approximately equal to A.S.A. Schedule 80 thickness for outside diameters from 3.5 in. through 16 in.; not less than Schedule 60 for 18 in. through 24 in., with 1-in. to 1 1/8-in. wall being the minimum for tubes 25 in. through 50 in. OD. These designations are synonymous with the former "extra-strong" pipe thicknesses through 10-in. pipe size. Generally, this means 3/8-in. minimum wall up to and including 7-in. OD tubes; 1/2-in. wall through 10.75-in. OD tubes; 5/8-in. wall through 14 in. OD, 3/4-in. wall through 22 in. OD, 7/8-in. wall through 26 in. OD, and 1-in. to 1 1/8-in. wall for diameters up to 50 in.

It is possible to produce centrifugally cast steel tubes with 1/4-in. walls through 24 in. OD, but these tubes are usually high-alloy steel and are furnished in short lengths of 4 ft to 9 ft. The experiences described herein are in connection with the manufacture of tubes having 3/8-in. to 5-in. walls in a range of sizes from 3.50 in. to 50 in. OD, and cast in sand-lined molds in nominal 16-ft lengths. Steel is melted in acid-lined electric-arc furnaces.

No basic changes in pipe-making machinery were required to produce centrifugally cast steel tubes. This was most fortunate, as the extensive pipe-making equipment available could be used to produce centrifugally cast steel tubes in an extensive range of diameters. A high-heat-resistant sand was necessary, and one composed of the following parts by volume has given excellent results: 16 parts clean silica sand; 2 parts bentonite; 2 parts silica flour; 2 parts fireclay.

This sand is mixed in a 2-yd muller. Permeability averages 115, green compression strength about 12 psi, and moisture approximately 6 1/2 per cent. Molds are faced with a core wash made up in a volume ratio of 1 part silica flour, 1.2 parts steel-wash paste, and 2 parts water. This mixture has a specific gravity of about 1.40.

Orifice pouring devices are required for best results. On tubes up to 12 in. OD, orifices are 1 1/2 in. to 1 3/4 in. diam, depending on the analysis, pouring temperature, and volume of metal to be poured. Similarly, 1 1/2-in. to 2-in. and sometimes 3-in-diam orifices are used on larger-diameter tubes 13 in. through 50 in. OD with the same factors governing choice of size.

RAMMING AND CASTING PROCEDURE

Cylindrical cast-iron flasks approximately 16 1/2 ft long are stood on end and centered on a rotating head which has a conical depression for receiving the pattern. At the opposite end the flask is likewise centered by guide rollers. A metal pattern is lowered into the flask and carefully centered at each end. Refractory sand is then fed into the annular space and thoroughly compacted around the pattern by pneumatic rammers. Sand linings are 1 1/2 in. to 3 in. thick, depending on flask size.

Thoroughness in compacting the sand cannot be too strongly emphasized as this minimizes tendency toward hot tears on the tube surfaces. A common mold-hardness testing machine would give values of about 90–92 for the usual rammed mold. After ramming of the mold is completed, the pattern is drawn leaving the mold cavity. The mold is air-dried, then faced with silica-flour wash, after which it is further dried by a gas flame.

Special care is taken to insure that the molds are well dried. Damp molds would result in heavy pitting of the tube surface and scouring of the mold during pouring. In the absence of better checking methods, we have assumed that a mold is completely dried when the temperature on the outside of the flask reaches 250 F.

When suitable stop-off plates, faced with hard-baked oil sand rings, are keyed into the flask ends, the flask-mold combination is ready for the horizontal casting machine. All flasks are dynamically balanced in a special flask-balancing machine. This is a most important requirement considering the speeds at which the flasks are revolved. Failure to do this may result in the flasks "whipping," with possible damage to the casting machine, and almost certain cracking of the tube during the initial freezing phases where hot strength is low.

Fig. 1 shows a typical machine with indirect drive, the flask resting on four rollers. Casting is "true centrifugal." The mold is spun about its own axis and utilizes centrifugal force imparted by the revolving flask to hold molten metal against the wall of the mold until the metal solidifies. The interior cavity is a true cylinder. This type of machine is well adapted to the rapid and economic manufacture of tubes in long lengths. The inside diameter and the wall thickness are determined by the volume of metal poured. Pouring temperatures range from 2750 F to 2950 F.

CASTING SPEEDS

Using the experience gained in manufacture of cast-iron pipe, a "favorable" mold speed at pouring has been determined as one that will give a force of about 75 times gravity, that is, 75

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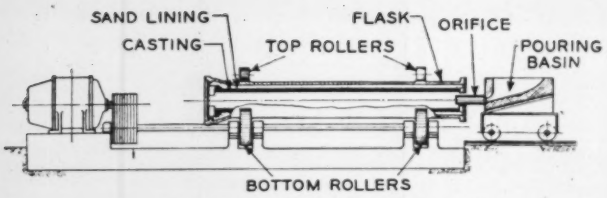


FIG. 1 TRUE CENTRIFUGAL MACHINE FOR LONG-TUBE CASTING

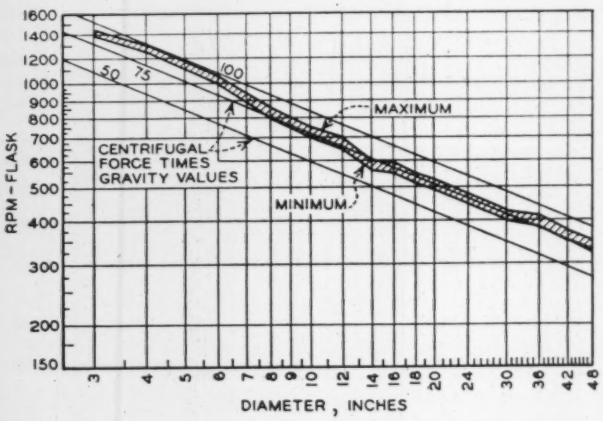


FIG. 2 TUBE-CASTING SPEEDS

lb pressure per pound of metal. By favorable we mean a speed that will provide sufficient force to place and hold the molten metal on the mold wall and at the same time squeeze out the impurities of lower specific gravity, such as dirt, slag, sand, and gas pockets.

In thick-walled castings it is necessary to select a compromise diameter for the 75 g to avoid having excessive force at the outside diameter.

A convenient formula to use in calculating centrifugal force in terms of "times gravity" is

$$g = \frac{N^2 \times \text{diam}}{70{,}500}$$

where g = number of times gravity
N = rpm
D = diameter, in.

Number of times gravity, g, can be calculated for both the outside diameter and the inside diameter, and a compromise speed selected so that g is at least 60 at the ID and, if possible, not over 100 at the OD.

Fig. 2 shows a typical diagram for speeds required to produce 50, 75, or 100 g in a large range of diameters. The shaded area indicates speeds which are used in most instances.

Spinning speeds are critical in determining to a large extent the soundness of tube castings. If the speed is too slow, the metal will not "pick up" on the mold wall, with resultant slipping or "raining" until the metal solidifies. This condition will cause laps and entrapment of foreign inclusions. At the other extreme, excessive spinning speed may produce high "hoop" stress, or circumferential tension, causing longitudinal hot tears. That these factors are not left to chance, is well demonstrated by the very complete casting data logged on each tube cast. These records furnish a large reservoir of knowledge and provide a check against performance.

After cooling, tube castings are mechanically stripped from the mold, subjected to magnetic-particle inspection, then heat-treated. After heat-treatment, tubes are shot-blasted on the outside and dry-ground on the inside, then machined, if required. Heat-treatment consists of annealing or normalizing and tempering.

STOCK ALLOWANCES

An essential consideration which always arises in the manufacture of centrifugal-cast steel tubes is the amount of stock allowance on the outside and inside diameters, where these surfaces are to be machined. An understanding between buyer and manufacturer on the type of surface required eliminates much confusion that could otherwise occur. For instance, pump casings, which are machined on the outside merely for truing up and are then painted, do not require as perfect a surface as do rotogravure rolls or glue rolls for labeling. In the first case, minor pin-point surface imperfections are not objectionable, whereas in the latter instance, such defects render the tube unfit for the intended service. On the other hand, in a hydraulic cylinder, the inside surface is critical, and must be clean for a sliding fit, consequently sufficient stock must be provided. However, certain types of rolls provide only $^1/_8$ in. stock on the inside, which is bored out for a press fit on a trunnion.

Our experience dictates the following general practice for providing stock allowance on tubes which are machined on the inside:

(*a*) Twenty per cent of the finished wall thickness to the side ($^1/_8$ in. minimum) for press fits and general structural purposes.

(*b*) Thirty per cent of the finished wall thickness to the side ($^1/_4$ in. minimum) for sliding and running fits, such as pump and engine cylinder liners where pin-point imperfections are not permissible.

It is probable that as methods and practices are improved, the stock allowances may be reduced materially.

Due to the inherent nature of centrifugal casting, the metal just below the outside sand-cast surface is the most dense and, correspondingly, the cleanest metal in the tube. This is proved in practice. Tubes of extremely heavy walls, such as 5 in. thick, clean up in machining on the outside diameter with a maximum of $^1/_4$-in. stock removal. The average is $^1/_8$ to $^3/_{16}$-in. machining allowance.

Fig. 3 shows a ring cut from a heavy-wall tube and deep-etched. The line of demarcation between the solid metal and the slag-admixture metal is clearly seen on the inside of the tube. Note that the band of surface metal on the outside is considerably narrower.

Although it is commonly accepted that centrifugally cast tubes have true directional solidification, cooling from the out-

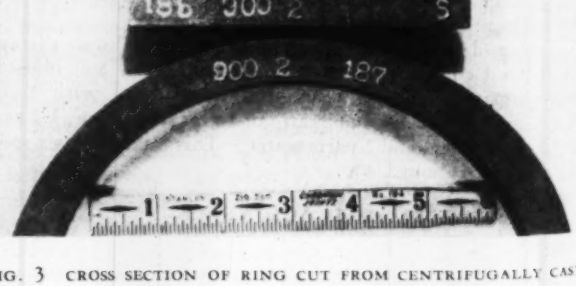
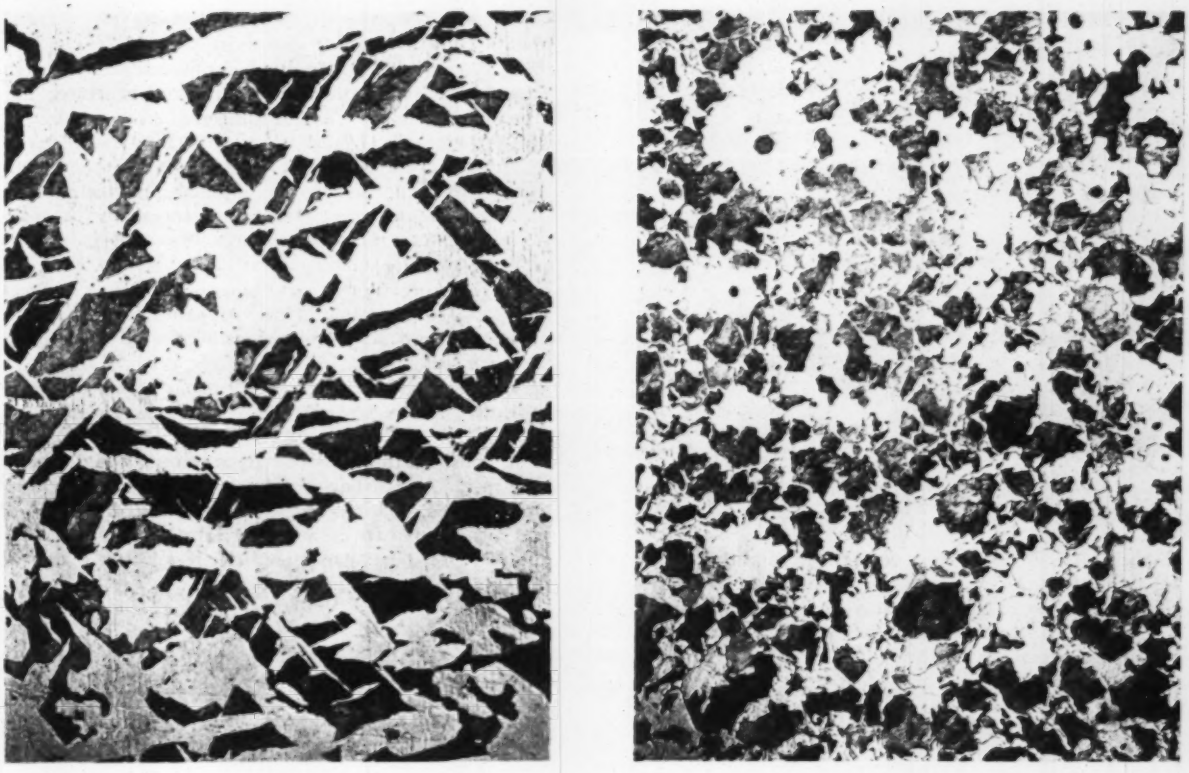


FIG. 3 CROSS SECTION OF RING CUT FROM CENTRIFUGALLY CAST STEEL TUBE



(*a*) (*b*)

(*a*, Shaft as cast. *b*, Annealed. Etched ×100.)

FIG. 4 MICROSTRUCTURES OF 16-FT-LONG SHAFT CASTINGS OF 0.30 CARBON STEEL

side inward, this may not be the case in thick-wall tubes, especially in the larger diameters. An analogism here shows that there is simultaneous freezing action from the inside diameter outward.

Fortunately, the refractory sand mold, being a better conductor, dissipates heat much more rapidly from the outside of the tube while the inside is insulated by a warm air blanket. Because cooling proceeds much faster from the outside, slag and foreign inclusions are driven to the inside surface where for the most part they are ground out in the cleaning operation. In very thick-wall tubes the boundary line between the slag strata and solid metal may extend somewhat further outward from the inside diameter.

Exothermic materials, or liquidizers, introduced on the metal in the ladle and placed on the interior surface of the tube immediately after casting, are of some advantage in keeping the metal liquid at the inside diameter to allow dross to work toward the tube inside and to reduce subsurface shrinkage.

In small-diameter alloy still tubes with approximately $^3/_8$-in. wall, the freezing action is so rapid that a very thorough grinding results in almost 100 per cent yield of serviceable material.

CAST-TUBE STRUCTURES AND PROPERTIES

The structures found in centrifugally cast steel tubes are not essentially different from those in any sound well-fed steel casting. A typical example is shown in Fig. 4, where we have the as-cast and annealed structures of thick-walled centrifugally cast 16-ft steel tubes.

Grain size of carbon- and low-alloy-steel tubes can be controlled to size 5 or finer where desirable. Grain size of high-alloy heat- and corrosion-resistant steel tubes may be varied within limits, depending primarily on wall thickness and pouring temperature.

Test specimens machined from the walls of centrifugally cast tubes give physical properties comparable to those obtained from separately cast keel-block test coupons, taking into consideration the known effects of section size. Of special significance are numerous tests indicative of the equal strength or load-carrying ability of centrifugally cast tubing in both the transverse and longitudinal directions. This is in contrast to the directional properties inherent in rolled tubing. This factor is predominant in designing for high-temperature service where creep properties are a primary consideration and also for internal-pressure designs.

At the present speeds used in centrifugal casting of thick-wall steel tubes there is a minimum amount of segregation. Whether or not this would be greater at higher speeds cannot be said, based upon our experience. Pouring temperatures probably would have greater effect. In very hot metal cooled very slowly, there would be the maximum amount of segregation. Chemical analyses on sections from some 0.30 per cent carbon 2-in-wall tubes show little difference from outside to inside. On these particular tubes, the carbon and sulphur contents ran a few points higher at the inside surface. The average variation in carbon was about 0.035 per cent and in sulphur about 0.004 per cent.

FIELDS OF APPLICATION

The field for centrifugally cast steel tubes is both large and varied. Applications proved in war are now generally accepted usages. It should be brought out that centrifugally cast steel tubing in the smaller diameters and in the usual carbon-

FIG. 5 FLUTED TUBES FOR SMALL ELECTRIC-MOTOR STATORS

steel grades is not competitive with the normal thicknesses of rolled and welded tubes. However, considerable economy will accrue where tubes in the high-alloy grades may be required, or for very heavy wall tubing, where physical properties are the major consideration. In addition, centrifugally cast tubes can be produced in special outside shapes, such as, square, elliptical, hexagonal, or with flutes, by the simple expedient of constructing suitable patterns. Where sufficient quantities are required, these shapes may prove very economical. Fig. 5 shows this type of casting. These tube castings serve to illustrate the accuracy which can be maintained on specification work. Tubes are as-cast $4^{3}/_{4}$ in. OD × $4^{1}/_{16}$ in. ID. Casting tolerance on the outside diameter was plus or minus $^{1}/_{64}$ in.

Tubes can be furnished with plain ends, threaded ends, or with screwed or welding flanges of the slip-on type.

Use of centrifugally cast stainless-steel tubes during the last few years in such installations as refinery stills and chemical retorts have demonstrated their ability to perform satisfactorily and economically.

Tests demonstrating the workability of centrifugally cast steel tubing have dispelled much of the misconception that such castings are "too stiff" for use in some industries. Fig. 6 shows representative tests on 4.75-in-OD × 0.80-in-wall × 16-ft-long centrifugally cast alloy still tubes 0.10 per cent carbon, 1.5 per cent chrome, 0.50 per cent moly steel, normalized and tempered.

The ability to secure long-length centrifugally cast steel tubes in a large range of diameters and to practically any analysis is of utmost economical value to the user or engineer in many instances. For example, a designer requiring three tubes of different diameters and thicknesses made from an expensive alloy steel may secure as little as a 16-ft length of all of these from the same furnace charge. He would probably experience some difficulty obtaining similar quantities of the desired alloy in the correct sizes from the high-production tube-rolling mills. In the high-alloy steels, these mills usually roll only the most popular alloys, such as, 18–8, 25–12, etc. These must of necessity be confined to the most used diameters and thicknesses otherwise, stocks would accumulate in slow-moving sizes. This is a problem of long standing. The foundry can produce centrifugally cast steel tubes from minimum heats of 2000 lb.

Many ingenious designers have taken advantage of the flexibility and economies of using centrifugally cast steel tubes. Even though many long-length tubes are employed in such uses as hydraulic cylinders, plungers, piston-rod sleeves, hollow shafting, and refinery-still tubes, a considerable quantity of 16-ft cast lengths are cut up into short-length cylinders for such services as gear hubs, ring gears, hoist drums, safety-seat rings, bearing backs, pump cylinders, motor and generator frames, and many other uses. These can be made to any desired stainless, alloy or carbon steel with equal facility. There is a broadening field for weldment applications and the present-day designers would do well to enlighten themselves on the possibility of utilizing cast-steel tubes in composite structures.

It is evident that there are various applications in industry requiring heavy-wall tubing, and it is in this field that the producer of centrifugally cast steel tubes can render a real service. Such applications as shafts, rolls, retorts, and others, where quantities are not large, cannot, as a rule, be serviced by the steel-tube rolling mills. In many cases, heavy-wall tubes have supplanted forgings in shaft applications or machinery parts. A hollow shaft is stronger than a solid shaft of the same weight.

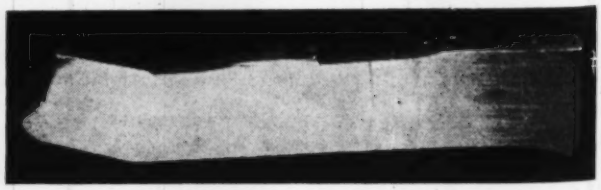
Some consideration has been given to centrifugally cast steel tubing in the low-carbon-molybdenum grades for use in power piping systems. This is an especially exacting service and requires a material capable of being fabricated into bends, etc. Preliminary tests have indicated the feasibility of cast tubes. The tests are being continued.

Flared 19 per cent, A.S.T.M. requirement

Flared to limit of testing machine

Flattened to 4 × wall thickness, A.S.T.M. requirement

Completely flattened without failure



Cross section of tube end which was rolled into still header box using a standard tool and a roll expansion of $^{12}/_{64}$ in. Note the sharp shear lines and flare

FIG. 6 TESTS ON ALLOY CENTRIFUGALLY CAST STEEL TUBES (Tests made in accordancewith A.S.T.M. Specification A200 for seamless tubing.)

TABLE 1 CASTING DATA—CENTRIFUGALLY CAST STEEL TUBING

Application	Type steel	Outside diameter, in.	Thickness, in.	Length, ft-in.	Weight, lb
Magnesium retorts	28% Cr-20% Ni	12.25	1.12	16-0	2106
Furnace rolls	29% Cr-15½% Ni	3.00	0.38	16-0	176
Still tubes	5% Cr-0.50% Mo	4.00	0.44	16-0	265
Still tubes	25% Cr-20% Ni	6.72	0.45	16-0	477
Steam superheater	27½% Cr-15½% Ni	3.92	0.43	16-0	253
Safety sleeves	9% Cr-1¼% Mo	6.12	1.00	16-0	865
Penicillin manufacture	18% Cr-10½% Ni	6.55	1.06	16-0	983
Shaft	5% Cr-0.50% Mo	8.50	2.25	16-0	2375
Radiant furnace	27% Cr-13% Ni	5.66	0.36	16-0	322
Pump cylinder	18% Cr-8% Ni-Cb	4.58	0.92	16-0	569
Pump liners	13% Cr-0.80% Ni	11.25	1.56	16-0	2553
Pump liners	17% Cr-12% Ni-3% Mo	5.80	1.15	16-0	903
Chemical retorts	AISI 310	34.80	1.62	12-0	6808
Paper roll	28½ Cr-9% Ni	19.60	1.49	11-6	3276
Forge-press bushing	SAE 4820	14.38	2.38	16-0	4824
Aviation gas turbine	25% Cr-20% Ni	21.70	0.73	8-6	1365
Aviation gas turbine	25% Cr-20% Ni	13.56	0.78	16-1½	1700
Shaft	SAE-6325	8.52	2.25	16-0	2400
Shaft	SAE-4140	7.00	0.92	16-0	945
Shaft	AISI 316	11.22	1.10	16-0	1880
Trunnions	SAE-1020	11.27	3.12	16-0	4295
Trunnions	SAE-1025	14.40	2.70	16-0	5335
Trunnions	SAE-1020	9.69	2.34	16-0	2905
Bearing back	QQ-S-681 Cl.2	14.40	3.95	16-0	6971
Bearing back	SAE-1015	25.00	2.50	12-0	7125
Bearing back	SAE-1015	8.63	0.86	16-0	1129
Gear hub	ABS Gr.1	18.24	4.00	12-0	7215
Shaft	ASTM A27-42-Gr A1	21.38	5.00	9-6	8212
Rolls	SAE-1030	17.60	3.12	16-0	7630
Stern tube	ABS Hull	33.00	4.00	8-5	10300
Screw conveyer	SAE-1025	18.30	3.80	12-0	6979
Machine part	SAE-1045	22.62	3.31	10-6	7100
Bushing	SAE-4150	25.00	3.25	11-0	8200
Machine parts	SAE-1025	26.00	2.50	12-4	7650
Machine parts	SAE-1025	20.70	2.50	12-0	5763
Rolls	SAE-1015	30.00	1.37	16-0	6647
Tug shafts	49-S1-B	8.52	2.50	16-0	2530
Destroyer escort shafts	49-S1-B Mod.	9.17	2.00	16-0	2420
Rolls	SAE-3115	5.50	1.75	16-0	1108

Table 1 lists in some detail casting data and uses for representative centrifugally cast alloy and carbon-steel tubes.

A clearer understanding of the practicability of centrifugally cast steel tubes can be gained by more detailed information on particular applications. Therefore more pertinent information is contained in the following accounts. Two cases are considered; one a carbon-steel tube application for ship shafts and the other a high-alloy-steel tube for chemical-retort service.

CENTRIFUGALLY CAST STEEL SHIP SHAFTING

Relying on the experience of Watertown Arsenal in producing centrifugally cast steel gun barrels for 90-mm guns, the U. S. Navy became interested in the feasibility of making cast-steel hollow ship shafts. Preliminary tests showed promise and centrifugally cast shafting for 20 destroyer-escort vessels was produced. Subsequently, a contract for tug shafting was executed. In turn followed a contract for producing large-diameter shafting for 13 Coast Guard Cutters of the Owasco Class. The vessels are 255 ft in length and require a propeller shaft approximately 44 ft in length, capable of absorbing the torque of a 4000-hp propulsion unit. It is this application which is described herewith.

A propulsion shaft is one of the most critical units of a ship's machinery. The units must render high-fidelity service under severe conditions. Primarily, a shaft is designed to transmit torque from the engines to the propeller. It is recognized that a hollow shaft, with its mass more efficiently placed, is stronger than a solid shaft of the same weight. Shear stress for cylindrical members under torsional loading is determined by the following formula

$$S_s = \frac{QD}{2J} = \frac{16}{\pi} \cdot \left(\frac{QD}{D^4 - d^4} \right)$$

where S_s = unit shear stress, psi
Q = torque, in-lb
D = outside diameter of shaft, in.
d = inside diameter of shaft, in.
J = polar moment of inertia, in.^{4}

In a solid shaft subjected to torsional loading, the shearing stress is zero at the geometrical axis of the shaft and increases in direct proportion to the distance from the geometric axis. Therefore it is a maximum in the fibers at the outer surface of the cylinder.

In a hollow shaft transmitting torsion loads, the inside fibers are subject to relatively low unit stress. Where the inside diameter is one half of the outside diameter, the ratio of shear stress at the inside fibers is equal to one half the shear stress at the outer fibers. This fact had been recognized by the Navy but, in view of the expense of removing this metal from a forged shaft, only large shafts for combatant vessels, where weight-saving was important, had been bored. In such cases the inside diameter was bored to approximately 0.6 OD.

Fig. 7 shows the fabricated and rough-machined line- and tail-shaft sections. Two centrifugally cast carbon-steel tubes were welded to solid forged coupling to make up the line shaft. One centrifugally cast carbon-steel tube was welded to a solid forged coupling on one end and to a solid forged tapered propeller mounting on the other end for the tail shaft. The forgings were 3.25/3.50 per cent nickel steel produced to Bureau of Ships' Specification 49-S-2 (Int.) These units were unique in

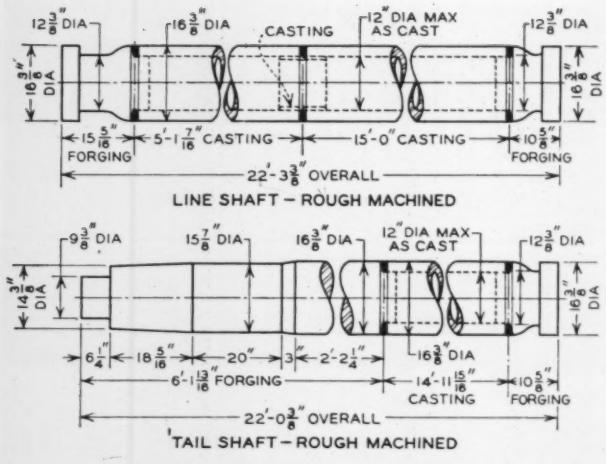


FIG. 7 FABRICATED AND ROUGH-MACHINED LINE- AND TAIL-SHAFT SECTIONS

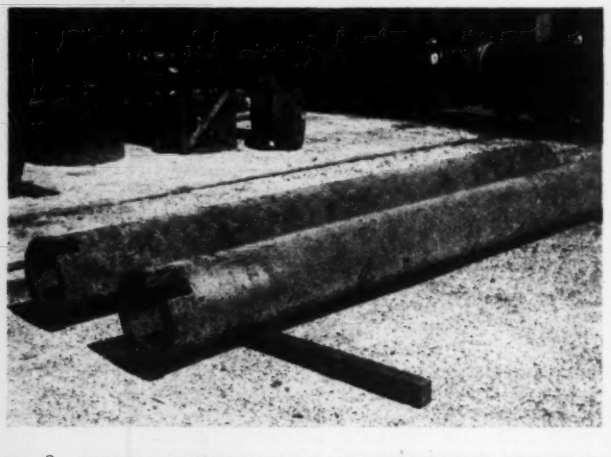


FIG. 8 AS-CAST CENTRIFUGALLY CAST CARBON-STEEL SHIP SHAFT WITH PLUGS REMOVED FOR TEST SPECIMENS

that it was necessary to develop a procedure for satisfactory welding of the nickel-steel forgings to cast carbon-steel shafting. Prior to this time such work had not been done. On the basis of research work conducted by the Engineering Experiment Station at Annapolis, a special welding technique was developed and has produced excellent results. All weld areas were stress-relieved in specially constructed refractory gas-fired furnaces.

In Fig. 8 are shown two centrifugally cast shaft tubes. As-cast dimensions are 16.65 in. OD × 12 in. ID × 16 ft long. Cast weight is approximately 7100 lb each. Note that, from one end of each tube, test coupons have been taken. These tubes were produced to Bureau of Ships, ad interim, Specs., 49-S-1 dated 7-1-42, except for chemical and physical requirements as given in Table 2.

TABLE 2 PROPERTIES OF CENTRIFUGALLY CAST SHAFT TUBE

Chemical Composition (Maximum, Per Cent)

C	Mn	P	S
0.35	1.10	0.05	0.05

Physical Properties

Test location	Tensile-psi max	Yield psi min	Elongation, per cent min	RA per cent min	1 1/2 in. × 3/8 in. bend
Cut from casting	90000	40000	20	30	120 deg around 1-in-diam pin

Average test results on 0.505 tensile bars cut from the tubes gave the following: Tensile strength, 75,000 psi; yield point, 44,000 psi; elongation, 27 per cent; reduction of area, 45 per cent. Steel was produced in acid-lined electric-arc furnaces and casting procedures were as described before.

After casting, tubes were cooled in the mold for 24 hr, then stripped, cleaned, inspected, and annealed in a batch-type oven at 1650 F for 2 1/2 hr, and furnace-cooled to 700 F before removal. Test specimens were cut from tubes after annealing.

Castings were rough-machined to 16 3/8 in. OD and, after thorough magnaflux and visual inspection, were machined at the ends for welding. Tube ends were counterbored slightly larger than 12 in. ID × 3 in. deep to give a smooth press fit on forgings and welding sleeve. The weld groove is detailed in Fig. 9.

After assembly and alignment of the machined shaft components, they were tack-welded in position and placed in electrically driven welding-jig rollers. The shaft was revolved to suit the speed of welding.

Welding was both manual and automatic, the latter being shown in Fig. 10.

Data on welding are given in Table 3.

TABLE 3 SHAFT WELDING DATA

Manual Welding	
Current	Alternating except first pass
Preheat	450–500 F
First pass	
5/32 in. A.W.S.E.-6010 rod	205 amp at 30 v, reverse-polarity direct current
Remaining passes:	
3/16-in. A.W.S.E.-9020 rod	215 amp at 30 v, alternating current
1/4-in. A.W.S.E.-9020 rod	245 amp at 35 v, alternating current
Time	16 hr
Automatic Welding	
Current	Direct
1/4-in. A.W.S.E.-9030 rod	325 amp at 28/30 v, straight polarity
Preheat	450–500 F
Time	8 hr

Preheat temperature was maintained during the course of welding by a gas burner directly under the center of the weld. Temperatures were checked with Tempil sticks ranging from 450 F to 550 F.

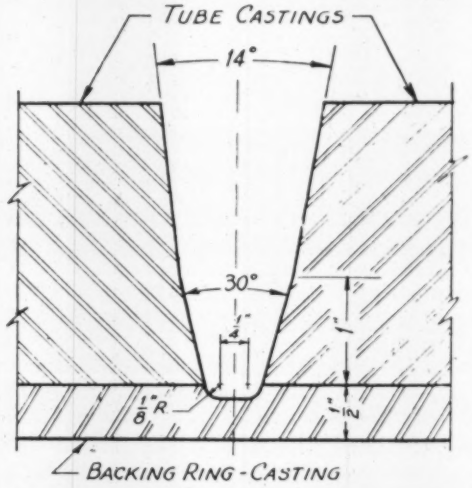


FIG. 9 WELD DETAIL APPROVED BY NAVY DEPARTMENT, BUREAU OF SHIPS

FIG. 10 AUTOMATIC WELDING OF CENTRIFUGALLY CAST CARBON-STEEL SHIP SHAFTS

During welding the shaft was constantly rotated in a direction toward the welder and at a speed equal to the rate of progression of the deposition. Electrodes were held at an angle of approximately 3 deg to the vertical, but normal to the longitudinal axis of the shaft. The electrode was oscillated, hesitating at the side walls long enough to wet the surface without undercutting.

The rate of progression in terms of a straight bead was such that 2 in. of electrode produce 1 in. of weld.

After welding was completed, the weld area was stress-relieved in a special refractory gas-fired furnace. Temperature readings were taken from a direct-reading contact pyrometer. The shaft was heated evenly at a rate not exceeding 350 F per hr to 1150-1200 F. This temperature was held 6 hr, then the shaft was cooled at a rate not exceeding 125 F per hr. The shaft was rotated constantly during the stress-relieving operation. Little differential hardness exists between weld metal and parent metal. Excess weld metal was machined off and a final magnaflux inspection was made. This method of stress-relieving gave straight shafting and obviated the necessity of using large and expensive ovens that would have been necessary to stress-relieve the entire shaft.

Fig. 11 shows finished machined line and tail shafts.

As a result of the very evident practicability of centrifugally cast steel tubes for Navy ship shafting, the American Bureau of Shipping approved a specification for this type of shafting in ships coming under its jurisdiction.

CENTRIFUGALLY CAST STAINLESS-STEEL RETORT

This application demonstrates the versatility of size in the employment of centrifugally cast stainless-steel tubes in the fabrication of a large vessel for chemical service.

In this instance, the designer considered two alternatives in the fabrication of these units: (1) By the use of rolled and welded plates to make up the cylindrical body section with end pieces to be forgings or castings; (2) the use of centrifugally cast alloy-steel tubes for the body section, with statically cast alloy-steel end portions welded to each end.

A decision was made to have entirely cast and fabricated assemblies. The acid electric-furnace steel used was Type AISI

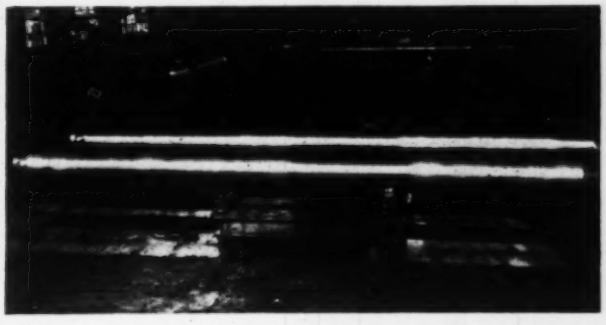


FIG. 11 FINISHED MACHINED LINE AND TAIL SHAFTS FOR COAST GUARD CUTTERS

TABLE 4 WELD PROPERTIES

	Tensile, psi	Yield, psi	Per cent elongation	Per cent R.A.	Impact, ft-lb	Bend, deg
MANUAL						
Longitudinal bend, weld at center	....	...	...	...	...	120
Longitudinal bend, weld at center	...	...	...	...	...	120
Transverse, all weld, tensile	81700	69300	22.8	52.8	...	...
Transverse, all weld, tensile	79300	70700	18.8	41.7	...	...
Longitudinal weld at center, tensile	76200	43400	...	...	...	...
	...	66500	...	...	...	...
Longitudinal weld at center, tensile	75700	43500	...	...	...	...
	...	66900	...	...	...	...
Charpy weld, center	...	...	...	...	32	...
Charpy, fusion zone	...	...	...	...	40	...
AUTOMATIC						
Longitudinal bend, weld at center	...	...	...	...	...	180
Longitudinal bend, weld at center	...	...	...	...	...	180
Transverse, all weld, tensile	77500	50700	27.1	56.7	...	...
Transverse, all weld, tensile	79200	52500	26.3	57.8	...	...
Longitudinal, weld at center, tensile	76600	50300	...	...	...	...
	...	51800	...	...	...	...
Longitudinal, weld at center, tensile	76700	48900	...	...	...	...
	...	50600	...	...	...	...
Charpy weld, center	...	...	...	...	43	...
Charpy, fusion zone	...	...	...	...	35	...

NOTE: In processing, the welds were magnafluxed after the first pass, stress-relieved by local heat-treatment at 1150–1200 F for 6 hr, and then remagnafluxed after the excess weld metal had been machined off.

310 Modified for these castings to the following analysis: Carbon, 0.25 per cent maximum; manganese, 2.00 per cent maximum; phosphorus, 0.04 per cent maximum; sulphur, 0.04 per cent maximum; silicon, 1.75 per cent maximum; chromium, 24/26 per cent; nickel, 19/22 per cent.

Test bars taken from keel-block test specimens showed the following average physical properties: Tensile strength, 74,600 psi; yield point, 35,900 psi; Elongation, 40.9 per cent; Reduction of area, 45.5 per cent.

Fig. 12 is a drawing of the fabricated vessel showing major dimensions.

In this instance no metal pattern was available which would permit casting to the desired outside diameter, including finish allowance for machining. A satisfactory and economical solution was found by utilizing an available standard metal pattern, and "lagging" up the outside by placing close-fitting wood staves around the circumference of the pattern to increase its outside diameter to the proper size. Refractory sand is rammed around the staves, thus forming the tube mold.

Tube sections are centrifugally cast 34.80 in. OD × 31.56 in. ID × 12 ft 2 in. long. The cast weight is 6900 lb. Pertinent data on casting are given in Table 5.

After tubes were stripped from the mold they were cleaned,

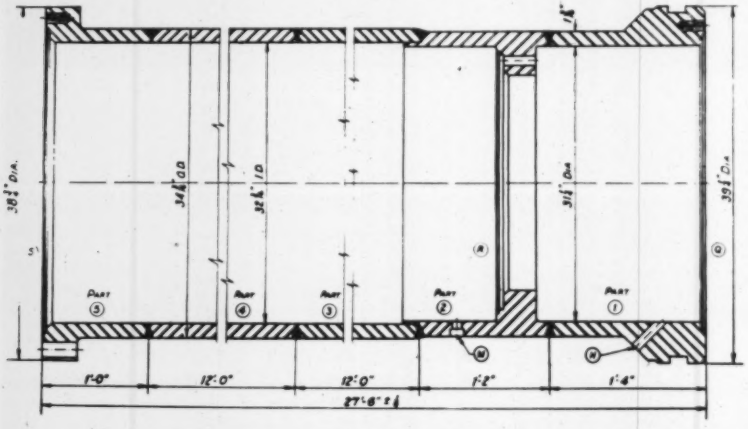


FIG. 12 DRAWING OF FABRICATED STAINLESS-STEEL RETORT

inspected, and machined to $34^{3}/_{16}$ in. OD × $32^{3}/_{16}$ in. ID × 12 ft long (approximately). Ends were machined for welding, employing male-and-female joint design with a $^{1}/_{8}$-in. radius at the root of the weld groove and the tangential bevels at 20 deg.

The two tubes composing the body section were welded first and later assembled by welding to the static cast end pieces to make a completed unit 27 ft 6 in. long.

Manual welding was employed throughout. Tubes were carefully aligned and tack-welded in position in the lathe where fits are made, then placed on welding-rig rollers where the welds were completed. The weld groove was preheated to 300 F, and this temperature was maintained during subsequent passes. Standard Type 310 steel lime-coated welding rods were employed. This type of rod is well shielded and has sufficient surface tension to produce the desired convex weld deposition. Procedure was as follows:

First pass, $^{5}/_{32}$-in. rod	20 v 100 amp
Second and third passes $^{3}/_{16}$-in. rod	22 v 125 amp
Subsequent passes $^{1}/_{4}$-in. rod	25 v 155 amp
Current	Reverse polarity direct current
Time	12 hr

Skip-welding was employed on the first two passes to eliminate warpage. To obviate any tendency toward cracking, low heat was used with welding progressing uphill. Heavy electrode deposit was made enabling the molten metal to

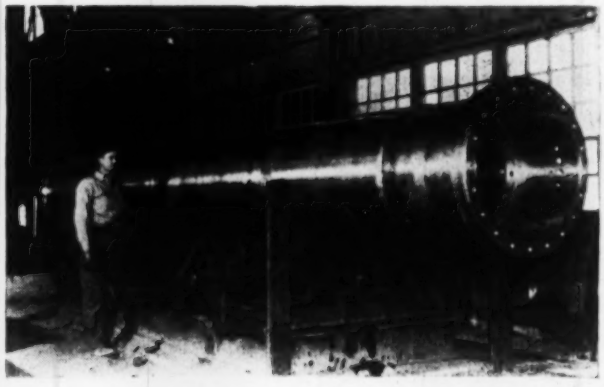


FIG. 13 VIEW OF COMPLETELY FABRICATED AND MACHINED 25 PER CENT CHROME, 20 PER CENT NICKEL STAINLESS-STEEL RETORT 27 FT 6 IN. LONG

(Hydrostatically tested at 300 psi and air-tested at 100 psi.)

run down under a heavy slag. Electrodes were positioned about 15 deg from the vertical and normal to the tube axis. A slow puddling arc break was employed to prevent crater cracking. Each pass was cleaned of slag, wire-brushed, and mechanically stress-relieved by pneumatic-hammer-peening.

TABLE 5 CASTING DATA FOR STAINLESS-STEEL RETORTS

Orifice size, in.	2
Pouring temperature, deg F	2780
Pouring time, min-sec	3–25
Flask speed at pouring, rpm	410
Casting time, hr-min	1–45
Ram time, min	18
Ladle additions	Carbon-free liquidizer

These fabricated units are pressure vessels for high-temperature service. Consequently, no heat-treatment is required and welds were not stress-relieved. Due to the weight, lengths, and precise machining required, it was necessary to machine component parts, fabricate into subassemblies, and finally weld these assemblies together to make the complete units. In view of the tight machining tolerances and the necessity for precise alignment, this was no easy matter. Fabrication procedure was in the following order: (Numbers refer to component parts in Fig. 12.)

1 Rough-machine sections 1 and 2.
2 Weld section 1 to section 2.
3 Machine inside and outside of sections 3 and 4 separately.
4 Weld section 3 to section 4.
5 Rough-machine section 5.
6 Weld section 5 to sections 3 and 4.
7 Finish-machine section 5 after welding to sections 3 and 4.
8 Finish-machine sections 1 and 2, and test between faces Q and R.
9 Drill holes H in section 1.
10 Weld sections 1 and 2, sections 3, 4, and 5
11 Test between faces R and S.
12 Drill holes M in section 2.

The subassemblies and completed vessels were hydrostatically tested at 300 psi and air-tested at 100 psi, while submerged in water. The alignment test required that a 32-in-OD × 2-ft-long wooden plug slide freely through the $32^{3}/_{16}$-in-ID cartridge. Ends had to be square with each other. Not more than $^{1}/_{4}$ in. maximum out of alignment was permitted. The assembled cartridge, shown in Fig. 13, weighs 12,500 lb.

COAL HANDLING *With* EARTH-MOVING EQUIPMENT

By R. L. HEARN[1] AND R. F. LEGGET[2]

BECAUSE of the vast quantities of coal used by modern industry during recent years, the problem of coal handling has become of major importance. The present paper deals with a solution developed from careful studies at the synthetic-rubber plant constructed by the Polymer Corporation for the Canadian Government in 1942–1943. This plant is located 3 miles south of Sarnia, Ontario, adjacent to the St. Clair River.

The plant was designed to produce 34,000 long tons of GR-S (Buna S rubber) and 6000 short tons of GR-I (Butyl rubber) per year.

Process-steam and power-generating capacity are supplied by the largest steam power station in Canada. The plant consists of five boilers, each with a steaming capacity of 308,000 lb of steam per hr at 415 psi, 650 F. Three steam-turbine units generate 29,000 kva at 6600 volts 60 cycles. For the supply of this station, it was estimated that approximately 650,000 tons of coal would be required annually.[3]

Special problems are presented by the coal which is shipped from ports on the Great Lakes for use in the United States or Canada. It may be noted that all this coal is moved in a period of about 7 months and so must be stored for use throughout the year at the plants at which it is to be used. Handling and rehandling this stored coal present further economic problems in relation to its utilization.

COAL-HANDLING PROBLEM AT POLYMER PLANT

In designing the Polymer Corporation plant consideration had to be given to handling a daily average delivery during the open season of navigation of about 3000 tons. It was anticipated that delivery of all the coal used would be by boat, with the consequent necessity for storing a considerable portion of the annual consumption. Provision naturally had to be made for alternative delivery of smaller quantities of coal by rail.

The following special requirements had to be met:

1 In so far as possible, the coal-handling arrangements had to be reliable and foolproof to assure an uninterrupted coal supply. Successful operation of a synthetic-rubber plant is wholly dependent upon continuity of processing, which makes the steam supply a critical factor.

2 The conditions existing at the time the plant was designed (1942) made strict adherence to economic factors even more stringent than usual.

3 The possibility of using fuel oil as an alternative to coal after the war had to be kept in mind, thus necessitating a minimum of expenditure on coal-handling equipment.

With regard to the delivery of the coal by steamer from ports on the Great Lakes, the following additional factors had to be given consideration:

4 The wharf structure provided had to interfere with existing river conditions as little as possible, in view of the critical location of the plant with reference to navigation and also to minimize danger from floating ice.

5 Since the contract arrangements for coal delivery were not known when the design was prepared, wharfage had to be provided based on the possibility of any type of lake boat being used to bring coal to the plant;

6 In view of war conditions, the use of steel-sheet piling for wharf construction was impossible.

Overshadowing the factors cited were the general limitations upon all construction projects, due to the exigencies of war and the consequent shortage of critical materials.

USE OF EARTH-HANDLING EQUIPMENT

Coal, in the form in which used commercially, is essentially a granular material of low specific gravity but with grading not very different from that encountered in some types of granular soil. This basic fact was recognized in the study of the Polymer coal-handling problem and attention was directed toward modern methods in use for handling soils.

So satisfactory have been general operating experiences with large-capacity earth-moving equipment in general, and in the experience of both of the authors, that the possibility of using this type of equipment for handling coal was given detailed study. Two favorable features were noted at an early stage: The low specific gravity of coal would mean that earth-moving equipment could be used to its maximum capacity without being subjected to anything like the stresses for which it was designed when handling earth. The nature of coal would mean that it would act to some extent as a lubricant to the bearings of movable equipment, being far different in this respect from the effect of soil which reaches similar moving parts. Other more detailed factors were given consideration, and, after the necessary study, a complete scheme of operation, utilizing earth-moving equipment almost exclusively, was drawn up and eventually put into operation.

COAL-HANDLING ARRANGEMENTS AT POLYMER PLANT

Fig. 1 shows generally the plan finally adopted for handling coal at the Polymer plant. A narrow timber-pile wharf was first constructed parallel to the river bank and 210 ft from it. The over-all dimensions of the wharf are 600 ft long × 20 ft wide. It was constructed as a timber-pile trestle with a solid timber deck but was so designed that in due course it could be surrounded by steel-sheet piling and thus be converted into a solid structure. The central section of the wharf (measuring 100 ft × 30 ft) was constructed as a solid timber crib in order that upon this section might be erected a timber hopper for receiving the coal upon discharge from self-unloading vessels. The entire wharf structure and approach trestle were so designed that they would carry the heaviest available movable crane, in case it should ever be necessary to use such cranes for unloading coal from vessels which were not self-unloading.

Carried on a trestle from the wharf to the river bank was a 54-in. belt conveyer, so arranged that it carried away the discharge from the hopper already mentioned, its theoretical capac-

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[3] "Polymer Power Plant," *Modern Power and Engineering*, vol. 38, May, 1944, pp. 63–93.

Contributed by the Materials Handling Division and presented at the Semi-Annual Meeting, Chicago, Ill., June 16–19, 1947, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

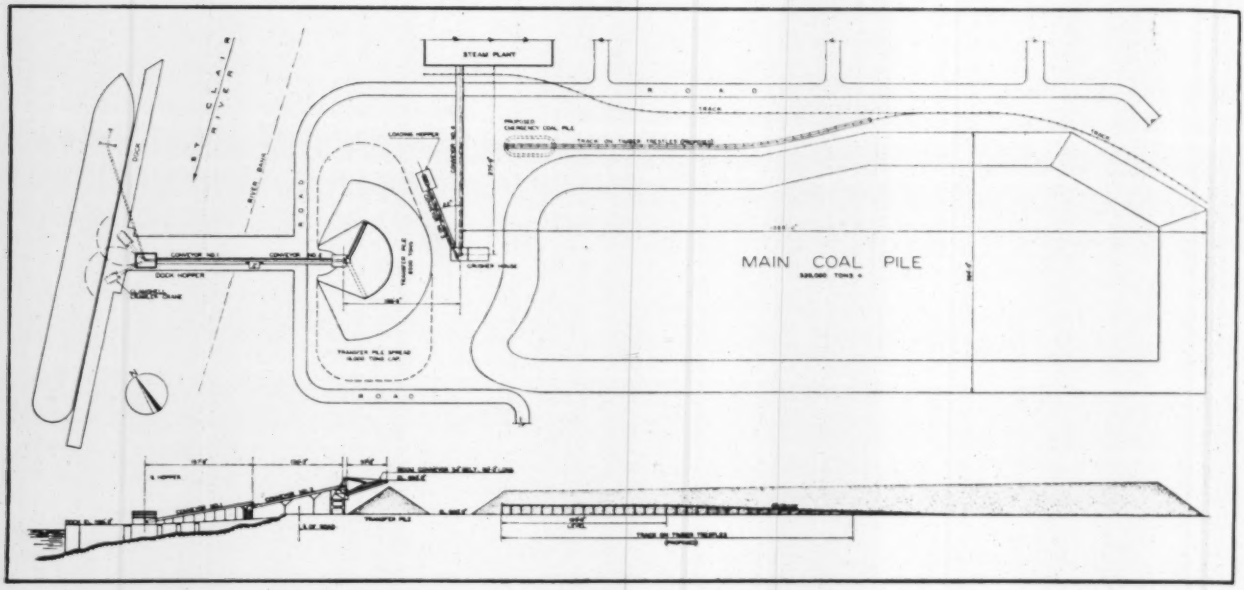

FIG. 1 GENERAL PLAN AND SECTION THROUGH COAL-HANDLING INSTALLATION AND STORAGE PILE AT THE POLYMER PLANT

ity being 1000 tons per hr to coincide with the maximum capacity of belt conveyers of most of the self-unloading coal vessels on the Great Lakes. A break occurs at the bank of the river; the first conveyer discharging onto a second 54-in. belt, in view of the change in the nature of the support. The second conveyer discharges through a revolving-boom conveyer which, together with the end of the main conveyer, is mounted on a light reinforced-concrete frame. This completes the only permanent equipment involved in the coal-handling arrangements up to the time coal reaches the crusher house, after which the installation follows standard practice.

After being discharged from the belt conveyers leading from the wharf, the coal is picked up in 15-cu-yd (heaped capacity) LeTourneau scrapers hauled by Caterpillar D7 tractors An additional D7 tractor equipped with a bulldozer is available for pushing the large scrapers when necessary and for general trimming around the coal pile. Carry-all scrapers take the coal from the point of discharge and spread it in relatively thin layers on the coal pile, which covers an area of approximately 400 ft × 1000 ft. The movable equipment has no difficulty in keeping up with the delivery of coal, especially since the movable discharge chute can swing through a wide arc, even though the coal comes in on vessels carrying 10,000 tons, arriving sometimes at relatively short intervals. The movable equipment includes one bulldozer, three Caterpillar D7 tractors, and three carry-all scrapers.

It may be noted that the tractors are equipped with crankcase, radiator, and track guards, front pull hooks, electric lighting systems, and fully enclosed specially fitted cabs. All the machines were used during the construction of the plant before being assigned to the special coal work.

Reclaiming the coal after the period of open navigation has closed is carried out with exactly the same equipment. The scrapers operate on roads which they themselves make, and scrape the coal off the pile in relatively thin layers, delivering it to a point adjacent to a sunken hopper from which it is fed by a belt conveyer to the crusher house. The coal is pushed into the hopper by a second tractor fitted with a bulldozer. This same piece of equipment pushes some coal directly from the point of discharge from the wharf to the sunken hopper during the period of open navigation.

SOME ADVANTAGES OF MOBILE EQUIPMENT

Quite apart from the basic question of cost, there are certain definite advantages in the use of the mobile equipment described, which were anticipated when the installation was designed, and which have been confirmed most definitely during the period of operation since the first coal arrived. These advantages may be listed as follows:

1 With the exception of the belt conveyer leading from the wharf, all the equipment in use can either be duplicated or replaced without delay, since it is standard construction equipment, and so always available on rental from equipment dealers.

2 The effect of the operation of the heavy tractors on the coal pile is to compact the coal to densities much higher than are normally encountered.

3 As a result of this compaction, the increase in temperature of the coal pile is minimized. Records suggest that the maximum temperature so far reached has not generally exceeded 90 F, although one "hot spot" was discovered in which the temperature had risen to 130 F. In consequence, the danger of spontaneous combustion is almost completely eradicated. The contrast between this record and the usual heating-up of ordinary loose coal is significant.

4 Due to the action of the scrapers in reclaiming the coal, an excellent and thorough mixture of the various types of coal delivered is obtained in the bunkers throughout most of the working season. In the case of modern plants, using large quantities of coal obtained from various mines, this feature is perhaps the most significant of all those listed.

5 Due to the compacting of the coal, and the elimination of the dangers of spontaneous combustion, it is possible to construct coal piles to heights previously unattainable. That at the Polymer plant has been carried to a height of over 40 ft, but a height of over 100 ft has been successfully used at another plant which uses the same method of coal handling. The great economy of storage space which these great heights make possible will at once be obvious.

SIMILAR COAL-HANDLING ARRANGEMENTS

During the study of the problem presented at the Polymer

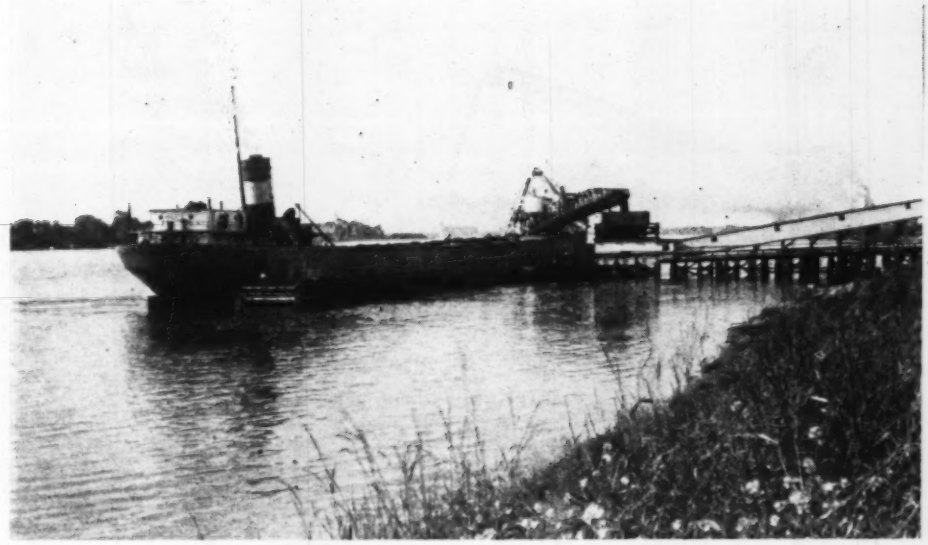

FIG. 2 SELF-UNLOADING COAL CARRIER OF 10,000-TON CAPACITY, UNLOADING INTO TRANSFER HOPPER ON WHARF

plant, a close search was made through engineering literature for details of coal-handling arrangements which might be suitable. Very little was found that was of assistance and nothing was noted with regard to the use of earth-moving equipment. Just after the arrangements described had been finally designed, the first published information about the new station of the Niagara Hudson Power Corporation at Oswego, N. Y., appeared in a paper by Messrs. N. R. Gibson and H. M. Cushing.[4] This paper described briefly a coal-handling installation very similar to that which was then proposed for the Polymer plant. This led to further inquiries being made, as a result of which it is possible to record the following information regarding other similar installations of mobile coal-handling equipment.

It would appear that the first use of "road-building equipment" for coal handling was a trial at the Huntley Street power station of the Buffalo General Electric Company in the year 1931, under the direction of Dr. Norman Gibson.[5] Additional coal-storing equipment was then required at short notice in the middle of the coal-storage season and a trial was made of the utility of road equipment. The trial was successful and by 1936 there were in use at this plant three 113-hp tractors, two equipped with bulldozers and one hauling a 12-cu-yd scraper, and one 75-hp tractor, equipped with bulldozer and hoist. On the basis of experience with this equipment, the coal-handling arrangements at the Oswego plant were laid out. At Oswego the following equipment is in use: Four 113-hp tractors equipped with angledozers and two 23-cu-yd scrapers.

The only other major plant at which coal is moved with mobile equipment of which the authors have knowledge is

[4] "Advanced Design—Original Features Embodied in New 160,000 Kw Oswego Steam Station," by N. R. Gibson and H. M. Cushing, Trans. A.S.M.E., vol. 64, 1942, pp. 541–565.

[5] "Coal Handling Systems for Central Stations," by G. C. Daniels, MECHANICAL ENGINEERING, vol. 63, 1941, pp. 801–806.

FIG. 3 GENERAL VIEW OF WHARF AND WHARF CONVEYER SYSTEM FROM THE POWERHOUSE ROOF

(Self-unloading vessel is discharging into transfer hopper, not seen, which is discharging onto the belt conveyers, the discharge from which is seen. Mobile equipment is in process of moving coal from discharge piles to the main storage area.)

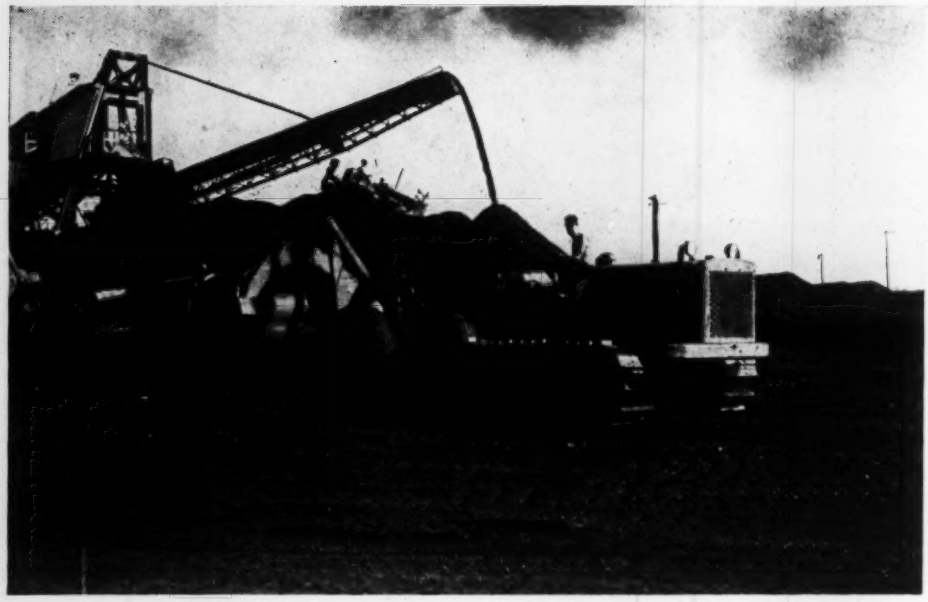

FIG. 4 LOADING OPERATIONS AT DISCHARGE FROM WHARF CONVEYER SYSTEM

(The tractor in the foreground, with cab removed, is hauling scraper during loading. The bulldozer on the top of the coal pile is grading this down to facilitate loading.)

that of the Dow Chemical Company at Bay City, Mich. Coal has been handled there using mobile equipment since 1937, the equipment being a 113-hp tractor and a 12-cu-yd scraper, together with a 55-hp tractor and bulldozer. A 3-cu-yd clamshell is used for the loading of about 100,000 tons of coal per year into railway cars for delivery to the company's plant at Midland, Mich.

The Anglo-Newfoundland Development Company, Limited, operating a large paper mill at Grand Falls, Newfoundland, receives all of its coal by rail. The coal is dumped from dump cars running on a low trestle and is moved into piles by tractor-operated bulldozers.

There are numerous plants which utilize tractors and bulldozers in addition to standard coal-handling equipment for smoothing off piles and for cleaning-up purposes. It is believed that the use of tractors for this purpose has increased rapidly during the last few years.

OPERATING EXPERIENCES

The first vessel to come alongside the wharf, the self-unloader *John Kling*, docked at about midnight on May 5, 1943. After a slight initial delay owing to the then incomplete installation of the belt conveyer, unloading proceeded as planned. Before the end of the open season of navigation, 1943, over 300,000 tons of coal had been successfully delivered and stored. Detailed operating statistics for the seasons of 1943, 1944, and 1945, are shown in Table 1. To these figures may be added two individual records. The largest single cargo of coal delivered has been 11,235 tons. The fastest rate of unloading so far achieved was from the steamship *W. F. White*, 11,103 tons being unloaded at an average rate of 1194.6 tons per hr. All coal delivered to date has been delivered by self-unloading lake vessels, so that it has not been necessary to use a crane on the dock for unloading nor to bring in coal by rail.

TABLE 1 OPERATING STATISTICS FOR COAL DELIVERIES TO POLYMER PLANT

Season	Coal delivered, tons	Days on which coal was delivered	Average coal per operating day, tons	Time lost in delays On wharf, hr	Time lost in delays On vessels, hr
1943	326587	51	6407	46	38
1944	179852	30	5995	6	0
1945	212000	36	5888	1	13

It has been found possible to operate the entire coal-unloading, storing, and reclaiming operation with one crew of workers. The drivers of the main tractors haul coal during the daytime only. When boats dock to unload cargoes at times other than during the regular working day, the regular crew turns out to handle the job at the usual overtime rates. The number of men in the coal-handling crew varies somewhat, but typical figures are as follows:

(*a*) Summer, when drawing coal directly from the pile under the dock conveyer to the crusher-house-conveyer grizzly hopper: 1 foreman, 3 conveyer men, 1 tractor operator (bulldozer).

(*b*) Summer, when unloading boats: 1 foreman, 3 conveyer men, 2 tractor operators (carry-alls) on shift.

(*c*) Winter, when reclaiming from the storage pile: 1 foreman, 3 conveyer men, 1 tractor operator (bulldozer), 2 tractor operators (carry-alls) 5 days a week only.

Some trouble has been experienced with dust rising from the coal, but by means of water sprays and, more recently, by having the coal sprayed at the loading dock with a 0.5 per cent solution of "Wetsol," the dust nuisance has been considerably reduced. The surface of the storage pile is graded up from the river end and at the same time is slightly "dished" across its width in order to minimize channeling of the sides of the pile due to concentrated surface-water flow. Toward the end of the shipping season this depression is gradually filled in so as to flatten out the surface and prevent accumulation of rain water. Before this precaution was taken, water was held on the surface of the coal in the central depression and naturally froze into ice, the removal of which was time-consuming. The fact that the coal is packed so densely that it will retain water in this way is significant.

One of the principal factors behind the final decision to use earth-moving equipment for handling the coal at the Polymer plant was naturally the low unit costs revealed by careful preliminary estimates. Based on a 5-year period for the depreciation of all equipment, the unit cost of handling the coal from the ends of the discharge conveyers of vessels, to the conveyer to the crusher house, proved to be 18.4 cents per ton. This was made up of 10 cents for operating, 1.5 cents for interest on capital invested, and 6.9 cents for depreciation.

Since the total sums represented by the last two items are no

variables, actual records of operating unit costs alone will be presented. Costs for all operations up to the delivery of the coal to the conveyer leading to the crusher house have been combined as in Table 2 which gives the unit costs, all in cents per ton.

TABLE 2 UNIT OPERATING COSTS

	1943	1944	1945 (to Sept 30)
Operating wages, cents	3.34	1.67	1.44
Conveyer maintenance, cents	0.11	0.40	0.06
Tractors and carry-alls (including drivers, fuel, and maintenance), cents	11.27[a]	3.71	2.61
Other costs,[b] cents	1.97	1.26	.60
Total,[c] cents per ton handled[d]	16.69	7.04	4.71

[a] High due to use of rented equipment.
[b] Includes conveyer electricity, sundry other overhead items.
[c] Costs exclude provision for depreciation and interest on capital.
[d] Unit costs obtained by dividing total costs by total quantity of coal handled; i.e., tonnage received for storage plus tonnage moved from storage for consumption.

These actual costs, as will be seen, compare very favorably with the original estimates. Indeed, if the unit cost for 1945 proves to be typical, original estimates may be found to have been unduly conservative. It is believed that, when compared with the unit costs for the more usual methods of handling coal, the figures obtained at the Polymer plant will be found to be unusually economical.

CONCLUSION

When the method of handling the coal at the Polymer plant, herein described, was first proposed it was generally regarded as impracticable, especially as it differed so radically from previously accepted coal-handling methods. Some confirmation of the soundness of the proposal was provided by the records of the few similar installations mentioned in the paper. It was not, however, until the complete system for handling the Polymer coal had been used for its first operating season that final confirmation of original anticipations was obtained.

So important are the operating economies thus made possible that the authors wished to make available to the profession the results of their studies as soon as they were thus demonstrated in practice. The requirements of wartime secrecy, coupled with the exigencies of war work, made the preparation of this paper impossible until recently. Delay in publication, however, has had the advantage of permitting the inclusion of operating results for three seasons. It is hoped that the operating statistics thus presented will enable those interested to compare the coal-handling method with other methods already in use and so to assess the economies possible under varying local circumstances.

ACKNOWLEDGMENTS

The Polymer Corporation, Limited, which built the Polymer plant, is a Crown Company, all the shares of which are held in trust for the Government of Canada by the Minister of Reconstruction and Supply, C. D. Howe, honorary member A.S.M.E., J. R. Nicholson is managing director of the corporation. The senior author served as chief engineer throughout the period of design and construction, being then succeeded by G. R. Henderson. J. A. Knight was assistant chief engineer during the construction period; the junior author assisted with some special problems, including that with which this paper is concerned. The steam power station and all other general services for the entire plant were designed by H. G. Acres and Company, consulting engineers of Niagara Falls, Ontario, under S. W. Andrews, chief engineer. The plant is now being operated by the St. Clair Processing Corporation Limited, for the Polymer Corporation; E. W. Dill, of the operating staff, has been most helpful in furnishing the authors with full particulars of operating results. Robert Hewitt of Toronto gave the authors much useful information in relation to the operation of the earth-moving equipment throughout the investigation of the problem of handling the coal.

BIBLIOGRAPHY AVAILABLE

A comprehensive bibliography of coal-handling methods, was prepared during the war by Dr. R. Ruedy of the National Research Council of Canada, and used by the authors. By special permission of Dr. C. J. Mackenzie, president of the N.R.C., this bibliography was included in the original of this paper. Separate copies of the bibliography may be obtained on application to the National Research Council, Ottawa, Canada.

FIG. 5 GENERAL VIEW OF COAL PILE FROM POWERHOUSE ROOF. THE SCALE OF PILE CAN BE GAGED FROM THE SIZE OF TRACTOR AND SCRAPER UNIT JUST TO RIGHT OF CENTER ON TOP OF STORAGE PILE

WHO WAS HOLLEY?

Engineering Profession Neglects Memorial of American Engineer

IN Washington Square at the foot of Fifth Avenue, New York, N. Y., close by the Washington Triumphal Arch, stands a weather-worn memorial to Alexander Lyman Holley, one of the pioneers of American engineering, founder and honorary member in perpetuity of The American Society of Mechanical Engineers.

On the column which supports a heroic bronze bust of Holley, the following words are inscribed: "To Alexander Lyman Holley, foremost among those whose genius and energy established in America and improved throughout the world the manufacture of Bessemer steel, this memorial is erected by engineers of two hemispheres."

On a day in October, 1890, before an international gathering of engineers, the monument was dedicated as an "expression of civic fame and human affection . . . . for the instruction and encouragement of generations." Ten thousand dollars had been contributed by engineers on both sides of the Atlantic to the Holley Memorial Joint Committee of the A.S.C.E., A.I.M.E., and the A.S.M.E. James Dredge, honorary member A.S.M.E., and editor of the London *Engineering*, had come to America to deliver the memorial address.

Recently, a New York reporter, noting the apparent neglect of the monument, asked, "Who is this man?" No one in the park could tell him.

One woman commented scornfully, "How delightful to erect a statue to one that invented steel. Where I come from (England), they erect statues to philanthropists, and poets, and humanitarians. It's a sad commentary on American life."

Another said, "I've read the inscription every time I pass, but I still don't know who he was. They ought to put a clock in his head so we'd know what time it is."

To engineers who cherish the memory of Holley, these words spoken in ignorance cut deeply, for they confirm what engineers regretfully acknowledge—that the story of American engineering has not been adequately told.

MAN OF PRODIGIOUS ENERGY

Holley was one of the great engineers to appear on the American scene, a lovable genius of many talents and prodigious energy, who burned himself out designing machines and developing the techniques of the Bessemer process so that the world might have cheap steel with which to build for the better life. His genius gave America the key to her industrial greatness. His techniques provided the substance eagerly sought by the nation's "captains of industry." He made the dream of transcontinental railroads and tremendous cities come true. So completely has his contribution diffused throughout the social structure, it can be truly said that wherever there is steel, wherever there is material prosperity in America, there also is a trace of the greatness of Holley.

Holley's talents covered the entire spectrum of engineering, but his career as an inventor and builder was centered mainly in the field of mechanical and metallurgical engineering. His experience as president of the American Institute of Mining Engineers and vice-president of the American Society of Civil Engineers made him aware of the need and the advantages of a national organization for mechanical engineers.

In his address, "The Field of Mechanical Engineering," read in his capacity as chairman of the Preliminary Meeting of the A.S.M.E., Feb. 16, 1880, Holley called attention to the scope of mechanical engineering by showing how the mechanical sciences underlay all the productive, constructive, and extractive activities of men, as well as those of transportation and national defense. The proposed organization, he said, would stimulate "the collection and diffusion of definite and much-needed information," would cultivate "personal acquaintance" among mechanical engineers, and promote "the habit of writing and discussing technical papers."

"Fifty men," he said, "can impart more information to one man than one man can impart to fifty."

The A.S.M.E. cherishes his memory as one of its illustrious founders. It was his personal charm, international prestige as an engineer, and above all his phenomenal energy and enthusiasm that supplied the impetus which carried the young organization through its formative months. His death, less than two years later, was a grievous loss.

Holley was known and loved by men whose hearts and fortunes were in things of iron and steel. In America, Great Britain, and on the Continent, doors closed to other men were opened to him. In any age of industrial-empire building, when

THE ALEXANDER LYMAN HOLLEY MEMORIAL IN WASHINGTON SQUARE PARK, NEW YORK, N. Y.

jealousy and secrecy were the order of the day, engineers, inventors, and industrialists were eager to disclose their plans and to listen to his criticism. With his brilliant mind brimful of engineering detail, his excellent memory retaining all that he heard, Holley was a welcome visitor because he could be counted upon to leave behind more than he took away.

A PARAGON OF AN ENGINEER

Holley was endowed with so many human virtues that he seems today a paragon of a man and an engineer. Well-proportioned physically, youthful and dashing, he had also a brilliant and creative mind, a pleasing voice, and a sparkling wit. He was a lucid writer and gifted speaker. Possessing a heart that was as open and generous as it was sincere, Holley's warm and genial personality was a rare combination of engineering sense, artistic talent, poetic insight, and philosophic understanding of men. But he had more. He had tremendous energy and above all a will to direct the power of his whole personality toward a good end. A smaller man would have done less but in Holley there was an urge to do the good deed which expired only with his life. No wonder then that Holley should have won the loyalty and affection of his friends, and that mechanics should have loved him as a brother. About Holley there was always a sparkle. He seemed always young. He died before he was fifty.

Born of a well-to-do family in Lakeville, Conn., July 20, 1832, Holley had the advantage of an excellent education. Displaying no love for the classical studies of the day, he was among the first students enrolled for the science course when it was inaugurated in 1850 at Brown University, Providence, R. I. As a student, he set his heart on building locomotives, and when his first job at Corliss and Nightingale, Providence, R. I., was not giving him the experience he wanted, Holley left the company to seek employment in a locomotive shop.

Young, eager, confident, with the world to conquer, he wandered about the country, haunting without success every shop where locomotives were being built. He watched the weeks fly by, hope diminish, and doubt torment his soul, but he lost none of his determination.

When at last he found employment with the New Jersey Locomotive Works, in Jersey City, N. J., most of his money was gone and some of his pride too. Forgetting temporarily his scientific education, Holley settled down to learn from the mechanics all details of the business and soon convinced his associates of his ability and energy. He had enough energy after the hard dirty work of the day to contribute to the *New York Railway Gazette*, edited by the former superintendent of the works, Zerah Colburn. Shortly after, he entered in partnership with Colburn and became an editor of the *Gazette* and later sole owner of the paper, whose name he changed to *Holley's Railroad Advocate*.

At the age of 26, Holley's name was known to most railroad men in America, but before he was a year older, his reputation was to spread to England and the Continent. In that year of business panic, 1857, he was forced to give up the paper. Acutely aware of the superiority of British railroad practice, Holley and Colburn convinced American railway executives that there was much to be gained by a study of European methods and volunteered to write such a report if their expenses would be covered.

REPORT INFLUENCES AMERICAN RAILROADS

Less than six months later, the two young men published their report, "American and European Railroad Practice," which had a terrific impact on American complacency. Inspecting, interviewing, traveling by day, analyzing, writing, drawing by night, they produced a comparative report of comprehensive scope which showed not only where and how European practice was superior, but also how the American industry could proceed to improve construction and operation. The report contained documented engineering data and complete drawings of European equipment which revealed engineering ideas far in advance of American thinking. While it disturbed American railroad men, the report was a tribute to English and European engineering and was received there with justifiable pride.

CLOSE-UP OF THE ALEXANDER LYMAN HOLLEY BUST SHOWING ITS MOTTLED APPEARANCE

STUDIES NAVAL ARMAMENT

Several years later, in 1862, Holley was again in Europe, this time intensively studying the implication of steel armor to naval craft. He was sent to obtain information which might be useful in the construction of the Stevens Battery, an armored ironclad, upon which the Government had expended more than half a million dollars without satisfaction.

From scattered official documents, observations of European operations, monographs, unpublished records, often obtained under great difficulty, Holley accumulated a mass of data on the art of naval armament such as could be found in no existing book. In 1864 he published his notes under the title, "Ordnance and Armament." The book was widely accepted as a standard textbook on the subject.

Holley's greatness as an engineer lay in his talent to comprehend the utility of things and in his ability to gather and digest facts and theories bearing on any engineering problem without prejudice to any side of the question, and to reach with almost unerring accuracy a true evaluation of a new idea or development.

Until 1864, Holley's career had been mainly one of brilliant engineering journalism. His inventive genius had been held in check by the full play of his critical faculties demanded by his journalistic employment. He had written books, he had

edited journals, he had served as foreign technical correspondent for the old *New York Times*. But after 1864, Holley was occupied to the exclusion of all else to the development of the Bessemer steel industry in America. That year was the turning point in his career. It provided the opportunity for which he was thoroughly prepared. It was the project which in the course of 17 years was to sap and finally stifle his enormous vitality and win for him the right to engineering fame.

For in the latter half of 1864, Holley was again in England, this time to buy American rights to the Bessemer process of making steel. Seven years before, Sir Henry Bessemer, honorary member A.S.M.E., had announced his idea for making steel cheaply by blowing air through a molten mass of iron. The invention had created a great bubble of excitement in the British steel industry. Vast sums were paid for licenses, but the bubble shortly burst, and in the wave of reaction which set in, the inventor and his process were temporarily discredited. Lacking knowledge of the chemical reactions involved, relying on unsuitable refractories and crude machines, commercial practice had been organized hastily and hopefully. Faith in the Bessemer process was at a low ebb and the poor steel from the converters gave ample evidence of its apparent uselessness.

But to Holley, who had been following the British developments with avid interest, the process had great potentialities. He spent his time in Great Britain studying operation. With remarkable accuracy, he put his finger on the weak points of British practice.

STEEL PRODUCTION IN AMERICA

The following year, 1865, his first plant in Troy, N. Y., was ready for production. In a few short weeks he was producing excellent Bessemer steel.

Once Holley demonstrated the efficiency of the Bessemer process, American investors lost their timidity and huge sums of money became available to Holley for designing and starting new operaitons. The American steel industry began to boom.

How did Holley do it? First, he did away with the British deep pit. He raised the vessels so as to get working space under them on the ground floor. He substituted top-supported hydraulic cranes for the more expensive counterweight English ones and put three ingot cranes around the pit instead of two, and thereby obtained greater area of crane power. He changed the location of the vessels as related to the pit and melting house and worked all the cranes and vessels from a single point. He substituted cupolas for reverberatory furnaces, and last, he introduced the intermediate or accumulating ladle which could be weighed before pouring into the converter. These points cover Holley's contribution to the American steel industry. Each was a radical departure from existing practice when it was made and necessitated new massive machinery, which he designed.

From his plans and under his direction, the finest steelworks in America were built at Chicago, Joliet, Pittsburgh, St. Louis, Cambria, Bethlehem, Scranton, and elsewhere. With prodigious energy, Holley devoted himself to the demands of the industry until his friends, despairing of his health, cautioned him "not to burn the candle at both ends." But Holley never knew how to be idle.

Under his leadership, American steel production soon far surpassed that of Great Britain. At one time, when Holley was escorting a British visitor, who had come to study American methods around one of his plants, the visitor remarked that he "should like nothing better than to sit down on an ingot mold and watch the work all day."

"If you want to find an ingot mold cool enough," Holley replied, to his admiring guest "you will have to send to England for it."

In 1880, when the founders of the A.S.M.E. were at work sketching the structure of the Society, Holley's health was already beginning to fail from the strain of his manifold activities. Into a professional career of less than 30 years he had crowded the work of half a century. The discredited process which he found in Great Britain had been transplanted and, cultivated by his genius, had blossomed into the greatest basic industry of the United States. He was known and respected all over the world.

Holley died in Brooklyn, N. Y., on Jan. 20, 1882. Still a young man—he was only 49—his heart and mind absorbed in engineering, aware of his impending death, Holley said to his friends around his bed, "I should like to live 10 or 15 years longer to aid in realizing the possibilities of the open-hearth process . . . . but I am satisfied."

In his career, Holley was basically a practical, characteristically American, mechanical engineer. He aimed always to facilitate, to simplify, to save labor, to economize. He was an engineer in the truest sense because he sought primarily to apply scientific knowledge to industrial processes to accomplish practicable ends. He left to others the search for fundamental knowledge, and schemes so visionary that only some generation, not his own, could find economical.

INSPIRED ENGINEERING PROFESSION

Holley lived through the era which in America saw the emergence of the engineering profession as a separate entity. He became a member of the A.I.M.E. in the first year of its existence and two years later joined the A.S.C.E. He provided much of the inspiration of our own Society. As an officer of these three Founder Societies in their early years, Holley's ideals, his life and personality, have been infused in that concept of the engineer which has been handed down to the engineering profession of our day.

Holley's name designates one of the highest honors conferred by the A.S.M.E. on any person "who by some great and unique act of genius of an engineering nature has accomplished a great and timely public benefit . . . . of such importance to be worthy of the gratitude of the nation and call forth the admiration of engineers." The Holley Medal was endowed by George I. Rockwood, past vice-president and Fellow A.S.M.E., to perpetuate the memory of Holley's genius. Since its creation in 1923, the Holley Medal has been bestowed on 15 inventors, industrialists, scientists, and engineers.

Otherwise Holley's heritage is alive only in the minds of engineers, the archives of engineering libraries, and a weather-worn memorial in a New York City park, a memorial whose legend for all its simple dignity does not adequately proclaim his place in American engineering.

ENGINEERS NEGLECT MEMORIAL

The engineering profession in America does a great injustice to its men and women and especially to its youth, who pause and wonder before a deteriorating memorial of a great American engineer, only to turn away without experiencing the glow of pride and humility in the life and achievements of one who, endowed with genius, used his talents to exemplify the ideal of American engineering and to give his country the sinews of its industrial strength.

When they notice the years pass without some token of remembrance, no wreath, no gathering of men to recall the legacy memorialized by the stones, no bronze plaques of engineering organizations claiming him as their own, it is no wonder that they should ask, "Who was this man?"—A.F.B.

FIG. 1 EQUIPMENT TO HANDLE STRESSCOAT BRITTLE COATINGS
(Spraying equipment on bottom shelf; calibrating equipment on top shelf.)

STRESS DETERMINATION *by* BRITTLE COATINGS

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INTRODUCTION

DESIGNING for strength and minimum weight requires knowledge of the complete state of stress on all parts of the structure and the properties of the materials used. The complete state of stress includes operating stresses, with particular emphasis on their fluctuation from mechanical and thermal loading, together with the locked-in state of stress caused by metallurgical and mechanical treatment of the material before assembly, plus stresses locked in by the assembly process. When the operating stresses fluctuate widely and often, it becomes necessary to know the state of stress in the smallest areas on any part of the structure because under such "fatigue" loading conditions the ordinarily ductile metals behave as sensitively to small areas of high stress as if the structure were made of brittle glass.

Since mathematics is inadequate for prediction of localized stresses on many structures, designers and the development men who have to fix the troubles not foreseen on paper are turning to experimental-stress-analysis techniques for answers to these important everyday stress problems. While the art of experimental stress analysis is not new, its practical use has taken a big step forward with the development of several tools within the last 10 years.

Since 1937 we have witnessed the practical development of the SR-4 type bonded electric wire strain gages, several short-gage-length extensometers, such as the General Motors photoelectric gage, and the "Stresscoat" brittle coatings. Each of these classes of strain-indicating instruments is pre-eminent in certain phases of stress-measurement work.

The electric bonded wire gages are small, of negligible mass, and simple and accurate in use. They are excellent for placing at a known point of stress in order to measure accurately the amount at the point and to follow the variation of that stress through any series of loading conditions, both static and dynamic. The extensometers are useful for accurately exploring localized areas of high stress. They can be readily moved from point to point, and an accurate survey made in a relatively short length of time.

The brittle coatings are unique in that they present an over-all picture of the stress conditions prevailing. Seeing the over-all stress-distribution pattern is often of major importance in itself in analyzing a stress problem. The qualitative picture of where and in what direction the maximum stresses occur is naturally a highly important piece of knowledge for later placement of extensometers or wire gages in order to measure accurately the stresses occurring there. In addition, by proper control techniques, the brittle coatings can be made to yield quantitative data of sufficient accuracy for most engineering purposes. The following discussion will describe the equipment used, the methods employed, and examples of results that can be obtained by brittle coatings measuring static stresses, dynamic stresses, and residual stresses.

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MATERIALS AND EQUIPMENT

Of the many brittle materials which might be applied to stress measurement, the one most used today is a brittle resin in volatile solvent-type-lacquer material. It is convenient to use because of the ease of application. Its main disadvantage is that the resin materials are sensitive to temperature variations and therefore are used where the temperatures are known and do not vary more than 5 deg F during the loading cycle. Application is by spraying rather than dipping or brushing because spraying is easier, and also because the peculiar property that small bubbles included into the coating improve the quantitative accuracy of the strain-pattern formation. Best drying time is 18 to 24 hr. Stressing the surface of a structure by adding load causes the brittle coating to fracture when a certain critical value of tension strain is reached. Patterns run at right angles to the principal tension stress. Patterns form at high rates of loading in the same manner as under static loading so that direct calibration can be made between the two types of loading. Patterns may or may not remain open after the load is removed. Fortunately for use in impact work the patterns can always be reopened by subsequent treatment with a dye etching material. Because the coatings are sensitive to temperature and humidity, it is necessary to use different coatings to obtain the same degree of sensitivity, i.e., the amount of strain necessary to initiate pattern formation, under different weather conditions prevailing on different tests. The graded series of brittle coatings serves another very useful function in that, at any one particular condition of temperature and humidity, a series of graded coatings will have different sensitivities over a wide range. For instance, it is practicable to choose a coating which will start to form patterns at any value of strain from 0.0005 to 0.005 strain, that is, from 15,000 to 150,000 psi stress on steel.

A uniformly bright background is a great help in observing the stress patterns easily. It also aids in applying the brittle coating by supplying a uniform background against which the thickness of the brittle coating gives a characteristic color. An aluminum pigmented undercoating provides an excellent background. By having it formulated in a thin solvent solution with materials which do not mix with the brittle coating, it is possible to apply the background undercoating and have it dry sufficiently within 15 minutes to cause no adverse effects in the brittle coating.

A red-dye etchant material serves several useful purposes. Formulated of solvent with a heavy concentration of organic dyes, the red-dye etchant reacts on the surface of the brittle coating in a manner similar to acid on steel. The organic-solvent etchant preferentially attacks any cracks whether visible or invisible to the eye in the brittle coating. Its use is of extreme importance in impact studies where it is not possible to view the patterns while under load, and furthermore, where the patterns usually close as soon as the impact ceases. The red dye in the etchant material also helps to delineate the pattern by working its way into the strain patterns and coloring them red. Another function of the dye etchant is to sensitize the brittle coating. If the dye etchant is applied to the surface of the brittle coating while the structure is under load, the brittle coating will be sensitized by 0.0006 strain. This means that if we started with a coating of sensitivity of 0.0008, loaded the structure, and immediately applied dye etchant, strains down to the value of 0.0002 will indicate by pattern formation. Furthermore, if the sensitization is started on a more sensitive coating of, say, 0.0005, then patterns will appear all over the surface.

Where there is no appreciable stress in the surface, the dye-etchant patterns will appear as small haphazard "craze" marks. However, where there is any appreciable amount of strain the craze marks will straighten themselves out into a definite pattern. In this way it is possible to investigate the stress distribution on structures made of exceedingly brittle materials such as glass, without any danger of overloading the structures. On steel, for example, it is possible to indicate stresses down to the order of 1000 psi.

Equipment necessary for proper utilization of these brittle coatings and accessory materials include spraying equipment to apply the coatings, a sling psychrometer, and a selection chart to pick the correct coating, calibration strips, calibrator, and strain scale to calibrate the sensitivity of the coating as used on each individual test. These pieces of essential equipment are shown in Fig 1.

METHODS AND EXAMPLES OF USE

From a quantitative viewpoint the critical value of strain which just initiates pattern formation is the most important measurement which can be made with a brittle coating. The change in spacing of the pattern with increase of strain above the initiating value is not sufficiently marked to allow for accurate calibration, except at the one value where pattern formation starts. The calibration strip, shown in Fig. 2, illustrates how patterns appear over a range of imposed strains.

FIG. 2 STRAIN PATTERNS IN BRITTLE COATING ON CALIBRATION STRIP AFTER LOADING IN CALIBRATOR

In order to make reasonably accurate quantitative evaluations, two techniques have been developed. The first and most readily applied to solid structures under controlled static loading is to note the different loads at which patterns just start to form at each area of interest. A simultaneous calibration of the coating for that particular test tells the amount of strain present when patterns initiate. These two sets of data plus the assumption that all local stresses are proportional to load allow for simple calculation of the stresses at all values of load within the elastic range. The other technique, which is of particular utility with dynamic loadings, is to repeat the same loading several times, each time with a coating of different sensitivity so that the amount of strain necessary to just start pattern formation can be judged.

STATIC LOADING

Probably the most widely used technique of testing is measuring stresses under static-loading conditions which simulate the worst loading conditions applied in service. Results are quite accurate, providing the loading in service is known, because there exists a direct correlation between the likelihood of fatigue failure in service and the amount of maximum tension stress disclosed by static tests. The usual technique is to use one coating of moderate sensitivity on the part. Loads of small and then increasing amounts are applied to the structure

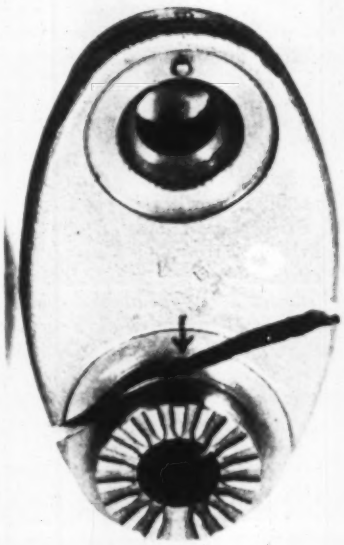

FIG. 3[1] SERVICE FAILURE OF CRANKSHAFT FROM EXCESSIVE BENDING STRESSES

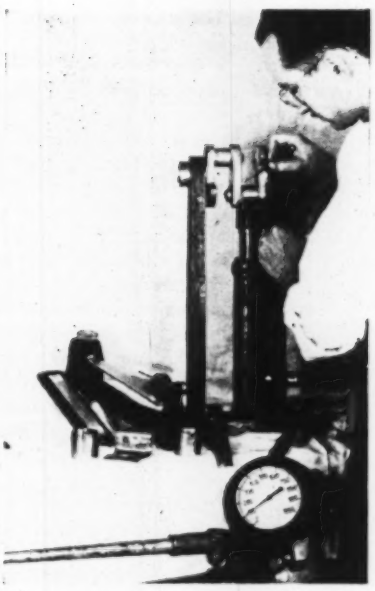

FIG. 4 STATIC BENDING STRESS BEING APPLIED TO CRANKSHAFT

stresses vary directly in proportion to loads with excellent accuracy. Then the amount of stress present at every area of interest is computed to a definite working load simply by multiplying the stress present at the given value of load when pattern formation first initiated, by the proportion of working load to the load at which patterns were first observed.

For example, observe the crankshaft record in Figs. 3 to 7, inclusive. Fig. 3 shows the service failure that was encountered. Examination indicated that fatigue failure originated exactly under the center of the pin. Bending stresses, caused by gas pressure and inertia loading, were believed to be the loading causing failure. A static-loading rig was set up, as shown in Fig. 4, applying load to the crankshaft throw by means of a hydraulic jack whose load was measured by the pressure gage attached. Increasing the load first produced patterns at the same spot as where failure originated in service. This correlation showed that the loading means was on the right path. By going to successively higher loads in increments of 20 per cent of the previous total load each time, the series of contours of load, as shown in Fig. 5, was drawn in. These indicated a

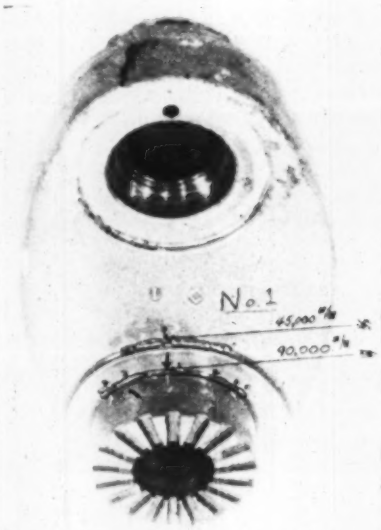

FIG. 5 BENDING STRESSES ON ORIGINAL CRANKSHAFT DESIGN

(Note concentration at center line of pin. Contours register spread of strain patterns with increasing increments of load each 20 per cent higher than previous one.)

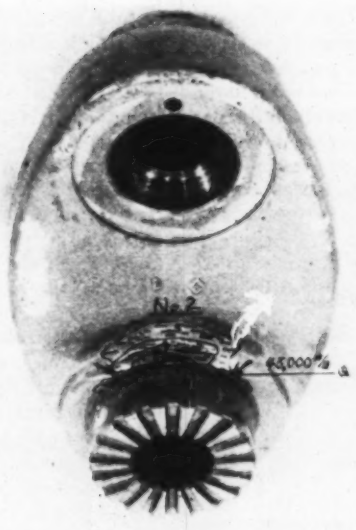

FIG. 6 REDESIGN WITH EXPENSIVE UNDERCUT FILLET

(Increase of 100 per cent in strength over original design.)

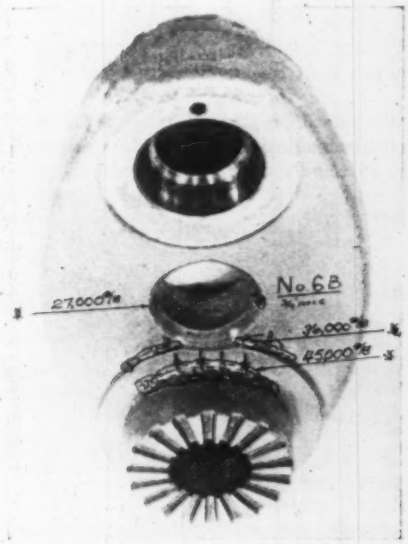

FIG. 7 REDESIGN WITH HOLE IN CENTER OF WEB AND INCREASED RADIUS OF FILLET

(Increase of 100 per cent in strength over original design. Note broad distribution of stress around center line of pin.)

in a controlled loading rig. Careful watch is kept for the initial formation of patterns in the brittle coating at all areas of interest. The loads at which initial patterns form are noted; usually by drawing a contour around the extremity of the pattern at each load. If the material is all operating below the elastic limit and the structure is of solid construction, and the loading system applies the loads in the same way at all values of load, then it is possible to use the assumption that local heavy localization of stress at the critical area which caused failure in service.

A modification in design was undertaken by increasing the radius of the fillet. A rerun in the same manner as before required 50 per cent more load before pattern formation initiated in the fillet. This showed that the shaft with the increased fillet was now 50 per cent stronger than the original. However, the stresses were still highly localized at the one critical spot.

In order to devise means of spreading the concentrated stresses

[1] Figs. 3 to 7 are by courtesy of Jack & Heintz, Inc., Cleveland, Ohio.

over a wider area, several changes in design were tried. These included the very beautifully cut undercut fillet, shown in Fig. 6, which gave a further increase of 50 per cent in strength when the undercut was carefully made to blend in with all surfaces. However, the undercut was not considered a satisfactory design from the manufacturing viewpoint.

Another modification, seen in Fig. 7, deliberately weakened the crankshaft in the web by placing a hole in the middle. However, this hole had the desired effect of removing a share of the stress concentration from the center of the pin and spreading it over a wider area. The proper-size hole arrived at after several tests gave the same amount of improvement as the best re-entrant fillet had shown and was much easier to manufacture. The combination of the hole plus the improved radius of fillet gave a 100 per cent increase in strength of this shaft. The changes put into production resulted in shafts which caused no further trouble in service. The question of weakening the web of the shaft by the hole was dismissed when the stress results showed that the edge of the hole in the web was still stronger than the fillet at the junction of the pin and web.

DYNAMIC AND SERVICE LOADINGS

When operating conditions permit, the simplest place to make an analysis is right on the job. Then there is no question of simulating loading conditions or even bothering about what they are. In spite of temperature sensitivity operation outdoors is surprisingly easy. The Weather Bureau does fairly well in predicting temperatures for the next day's test. Of further help is the normal cycle of outdoor temperature from a low around 7 a.m. to high around 3 p.m. and then back down. If conditions are not right when starting test a few hours' wait ordinarily brings them. Coating and overnight drying are done indoors. Dye-etching after loading is done outdoors. Service loading testing is particularly valuable under impact loading such as the firing of guns whose loadings may be extremely difficult to reproduce by simulated static tests.

FIG. 8 PATTERN ON SHOTGUN AFTER FIRING AND DYE-ETCHING
(Patterns formed on areas with 25,000 psi or more.)

FIG. 9 SHOTGUN WITH LESS SENSITIVE COATING, REQUIRING 35,000 PSI TO INITIATE PATTERN

The method of operation is well illustrated in Figs. 8 and 9, showing analysis of a shotgun. First the gun was coated with a brittle coating which initiated patterns at 25,000 psi. The shotgun was fired and immediately dye-etched. All patterns that appear in Fig. 8 show stresses of 25,000 psi or more. Since the stress at the extremities of all patterns must be 25,000 psi, a contour drawn around the edges of all patterns has the known value of 25,000 psi.

In order to evaluate higher amounts of stress in the center areas already covered with patterns, another test was made with a new coating requiring the higher amount of 35,000 psi to start pattern formation. In Fig. 9 the same shotgun now shows patterns requiring 35,000 psi or more.

In order to hunt down the exact values of the highest stresses on the gun, it would be necessary to make one or more further tests with coatings which would start to fracture at, for example, 50,000 psi and 75,000 psi. When the results of these several tests are assembled, it is quite simple to evaluate the stress at any point simply by noting the maximum valued stress pattern which appears at that area.

If only one test specimen is available, the testing period is extended to several days' duration because the drying of each coating requires the time of 1 day. However, when several similar models are available or if the structure is a symmetrical body as, for example, a fan with several blades of similar design all radiating in the same manner from the hub, it is possible to coat each of the similar models or each of the similar parts of the same structure with different sensitivities of coating and then load and dye-etch all at the same time.

Actually, in developing a design and after some experience has been had in previous stress tests, it requires only a few tests on each design modification to establish whether results are better or worse than they were previously. The temperature limitation on such tests is primarily that temperature must not vary during the test. Since only one cycle of load is required for the coating to react, it is quite possible to run most structures such as fans and motors for such a short duration of time that no appreciable rise in temperature can occur. Testing is not necessarily confined indoors since coatings can be obtained for operation at temperatures ranging from 20 to 120 F. It is necessary, however, that the coating be selected for operation at the temperature occurring during test.

Residual stresses locked up in the material by metallurgical and mechanical treatment can be indicated and measured by a technique involving the drilling of a small hole at any area to be investigated. A $^1/_8$-in. drill is ordinarily used, although drills as small as $^1/_{32}$ in. are used in small areas. Tungsten-carbide-tipped drills are capable of drilling into material above Rockwell C 60 in hardness. The drilling of the hole relieves residual stress in the vicinity of the hole. The brittle coatings will react to show a star pattern of lines originating from the edge of the hole if residual tension was present, or circular patterns surrounding the hole if residual compression was present.

Details of the technique are first to use a brittle coating of sensitivity of 0.0003 to 0.0006. The hole is drilled carefully through the dried brittle coating and into the material beneath. Heating of the material is avoided by using slow speed and high pressure on hard material. Drilling is done to a depth equal to the diameter of the drill. Immediately after drilling, dye etchant is applied on the surrounding brittle coating. Usually patterns do not appear when the hole has been drilled but, after applying etchant for several minutes, the sensitizing action of the etchant will then produce a distinct pattern around the hole. Beyond the distinct pattern will be seen small craze marks where the coating has been sensitized by the dye-etchant action but there is no prevailing direction of stress. The amount of residual stress present is noted by the number of

diameters of the hole that a regular pattern appears away from the edge of the hole. Each diameter represents approximately 0.0007 residual strain, that is, 20,000 psi on steel per diameter of hole.

The sensitivity of the coating is critical to the extent that the coating must be sufficiently brittle to produce the craze pattern under the sensitizing influence of the dye etchant in areas out beyond the pattern formation.

Fig. 10 shows residual stresses along a seam weld between two $^1/_8$-in. sheets of common steel. The upper pattern with its long radiating patterns indicates residual tension of considerable amount. The lower pattern shows the compression reaction in the plate about $^3/_4$ in. away from the weld.

Fig. 11 shows patterns on a small aluminum-alloy forging of complex shape after heat-treatment. The predominating residual stress is compression, as would be expected on the surface of any quenched body, but the variation in amount and direction are interesting. Of particular note is the residual-tension pattern existing in the corner between the central heavy body and adjacent thin section.

The last example of induced stresses, shown in Fig. 12, is not on metal but on a molded phenolic plastic which has been wet on the back and dry on the front face for a month. The absorption of moisture on the back surface of the $^1/_8$-in-thick

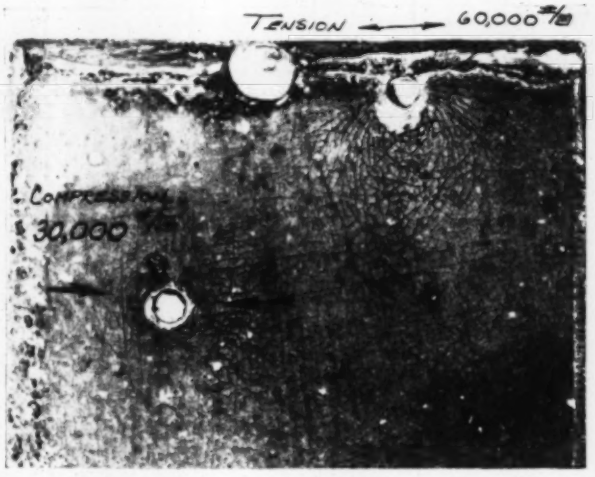

FIG. 10 RESIDUAL STRESSES ON WELDED PLATE
(Tension stress next weld. Compression stress $^3/_4$ in. away from weld.)

FIG. 11 RESIDUAL STRESSES ON FORGED ALUMINUM ALLOY AFTER HEAT-TREATMENT
(Amount indicated on representative patterns. On aluminum it is approximately 7000 psi per diameter of drilled hole away from edge of hole.)

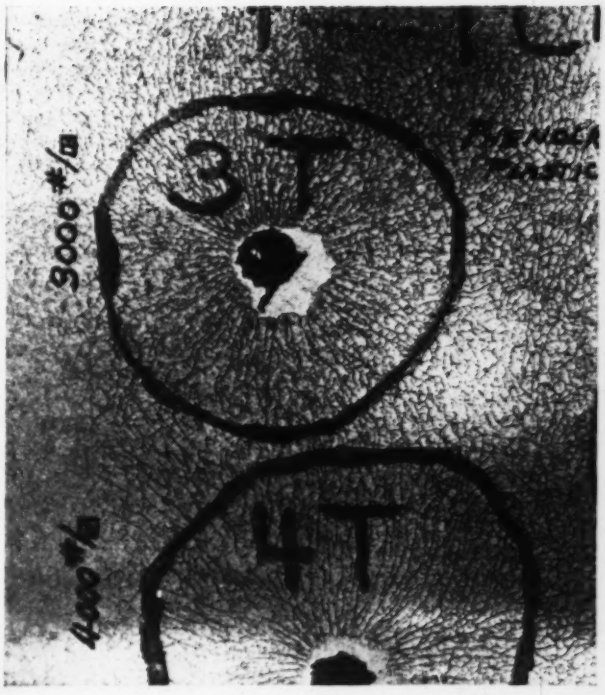

FIG. 12 INDUCED TENSION STRESSES ON DRY SIDE OF FORMED SECTION OF PHENOLIC PLASTIC CREATED BY EXPOSURE OF OPPOSITE SURFACE TO 100 PER CENT HUMIDITY FOR 1 MONTH

section has produced a general compression stress there, creating a tension reaction on the dry face as shown. This differential moisture-absorption phenomenon can continue to the stage of failure of the plastic from the stresses induced.

Stresses locked up by assembly operations are easily evaluated by coating the free parts and then assembling them. The tests may be repeated several times with coatings of different sensitivities in order to get quantitative accuracy of results in a manner similar to that previously described for impact test on the shotgun.

Thermal stresses are not evaluated directly with the present temperature-sensitive brittle coatings. However, the thermal loadings can often be replaced by a mechanical load simulating the thermal effect and similar stresses shown.

CONCLUSION

Experimental stress-analysis methods offer short cuts to the designing of stronger, lighter, and cheaper structures. Brittle coatings are powerful and versatile stress-measuring tools of sufficient accuracy for design-improvement purposes. Disadvantages of present materials, particularly their sensitiveness to temperature variations, can be overcome to a large extent with careful handling by skilled operators.

BIBLIOGRAPHY

1 "Methods of Stress Determination in Engine Parts," by Charles Lipson, *S.A.E. Journal*, vol. 51, April, 1943, pp. 105–124.

2 "Improving Engine Parts by Direct Measurement of Strain," by R. G. Anderson, *Journal, Society of Automotive Engineers*, vol. 54, Sept., 1946, pp. 466–475 and 502.

3 "Continental Finds Stresscoat Analysis Valuable Guide in Redesigning Engine Parts," by Joseph Geschelin, *Automotive and Aviation Industries*, vol. 95, Aug. 15, 1946, pp. 36–39 and 100.

4 "Brittle Coatings for Quantitative Strain Measurements," by A. V. deForest, Greer Ellis, and F. B. Stern, *Journal of Applied Mechanics*, Trans. A.S.M.E., vol. 64, 1942, p. A-184.

Improving LABOR EFFICIENCY *in* DAY-WORK FACTORIES

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THE question is frequently asked, "Can anything be done in a union day-work shop to improve direct labor efficiency?" The answer is definitely, "Yes!" Here are some of the plans that are now in successful operation over the country:

Keep Hourly Production Records. The greatest single loss in efficiency of the day-work operator is not his deliberate slow pace in most cases but his lack of consistency; he just will not work 7 or 7 1/2 hours a day (for 8 hours of pay), unless someone is standing over him or checking him throughout the day.

Such hourly figures are collected in two ways: (*a*) Every hour by a foremen's clerk; and (*b*) at the end of the day after the operator has recorded them himself.

In one shop with which the author is familiar, daily production curves are kept (by the hour). These curves are mounted on stiff board. They last a week. The foreman or anyone else passing through the department may see these curves hung directly in front of the operator. Unusual low points might be questioned and high points might be commended. At the end of the week the curve is turned in to the foreman who inserts it into his book. Thus, a visual record of the operator's contribution—by the hour—is kept at all times.

Posting Operator Efficiencies. This is done on a daily basis in some plants and on a weekly basis in others. Before any such "public" airing of personal efficiency takes place, it is well to do this privately for several weeks. Thus no one is unfairly embarrassed. It is surprising how even the most recalcitrant and vicious union member will finally yield under such a campaign; for few people are willing to see their names at the bottom of the list day after day.[1] The result is usually one of two things: (*a*) Either the operator goes up in her efficiency, or (*b*) she voluntarily quits. In either event the end result is favorable.

A foreman may experience a situation in which an entire group or even an entire department will peg its production so as to come out with the same daily efficiency (say, 75 per cent). Such a situation requires very careful handling. This is a difficult problem to solve; the maximum of sales or managerial effort is required, perhaps, with a concentration on one group.

Vestibule-School Isolation. The situation just described is one of the most difficult to solve, especially where the condition has persisted for several months or years. At least three factories to the author's knowledge are using the vestibule-school idea in a number of ways:

(*a*) When a new worker is brought in, she is taught her job away from the others, privately. She learns for herself at the end of a week that 100 items per hour is fair performance on her job—not 75; that 100 per hour allows her 1/2 hour a day for personal needs, and a small amount for recreation; that the company although paying her for 8 hours of work expected her to do only 7 1/2 hours (750 units per day).

The big test comes when this new operator is put out in the shop with the others who have deliberately pegged their production at 75 per hour. Unless this situation is watched carefully, the new operator, under the impact of group pressure, will swing back to 75 per hour—or quit. The following method may have to be employed in this event.

Fire or Threat of Dismissal. Because of the seniority clause in most contracts, it is becoming increasingly difficult to fire or to lay off anyone except on a seniority basis. But the door is not entirely closed in those situations where an operator is obviously neglecting his job. What constitutes neglect of job (according to recent arbitration decisions)?

(*a*) Excessive high absentee (and tardiness) rate, compared with the department or factory.

(*b*) Excessive violation of company rules especially safety, compared with the department or factory.

(*c*) Excessive spoilage or waste of materials and tools, compared with the department or factory.

(*d*) Substandard deportment (fights, drunkenness, excessive profanity, and stealing), compared with the department or factory.

(*e*) Sleeping on the job.

(*f*) Substandard production or workmanship, compared with the department or factory.

It is better usually to work closely with the steward under any of the foregoing. Indeed, he might even correct the trouble if the sequence of steps is outlined for him. He, then, can lay the whole thing "on the line" for the operator or group.[2]

Redesign the Job. If a works manager has been putting in 30 hours a week for years and his board of directors suddenly asked him to work 40 hours without any increase in pay, there probably would be a natural resentment—despite the fact that for years he had been "getting away with murder"—doing three-quarters of a week's work for a full week's pay. Workers who have become accustomed to a certain pattern of work habit come to believe honestly this is a fair pattern. Changing their thinking is difficult.

An approach that is working successfully in one plant is that of complete retooling and redesigning the job. When all else fails, the job is taken out of the shop and put into the master mechanic's department. The industrial engineer and the master

[1] In one plant where this was tried, a foreman lost his nerve after an operator (union steward) threatened to sue him for libel if he did not remove her name from the list entirely. Not knowing the law on slander and libel, the foreman backed off and did not try the thing again.

Contributed by the Management Division of The American Society of Mechanical Engineers.

[2] A superintendent some years ago related an interesting way in which he handled a difficult group situation. The group had demonstrated to him and to its members that each individual could do 110 items per hr. A standard of 100 per hr had been set. However, they refused to budge from 75—both the day and night shifts! To complicate matters, the worst offender and ringleader in this production group was a union steward. The superintendent said he planned to fire them if they did not come up in production. The author foresaw the possibility of a strike ensuing from such an action so he asked, "All at once?" "No," said the superintendent, "one at a time." The author said, "I suppose you will start with the worst offender first—the union steward." He said, "No, I'll start with the least guilty first and save the steward until last."

(*Continued on page 584*)

Developments in FUELS, LUBRICANTS, *and* LUBRICATION

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HIGH-OCTANE GASOLINE

OCTANE value of gasolines, to serve higher-compression-ratio engines, has been tremendously pushed for some years, and beautifully deceptive charts have frequently been published showing that all the gain in horsepower has been due to octane rating. Many have thought that because 100-octane gasoline (and higher) had to be made for warplanes, we should be using 100 octane in passenger cars shortly. This foolish idea needs deflating. In the first place, 100-octane gasoline for general use would cut the total production 40 or 50 per cent, by present refining methods. This we could not possibly afford. Next, there is no present engine designed that would be satisfactory for passenger service at compression ratios of 8.5 or 9 to 1, required to get the full benefit of 100 octane. The designers inform us that since rate of pressure rise increases sharply with compression ratio, they do not yet know how to control roughness in an engine at these high ratios.

Preignition has also shown up pronouncedly as compression ratio increases, and it seems likely that further increase in compression ratio will result in aggravating preignition troubles, especially if the engine has a high natural octane demand, or is not kept clean in jackets and combustion chamber.

With regard to further power and economy gains by increase of compression ratio, we must remember that the law of diminishing returns is still operating. In 15 years we advanced from 5 to 6.8 and gained theoretically about 15 per cent in power or economy. We are now on the flat part of the curve and less than 10 per cent is all that can possibly be obtained by advance to 9:1, as shown in Fig. 1, and Tables 1 and 2. We should also take note of the fact that only 20 per cent of the horsepower increase in the period 1930 to date has been from compression ratio; the rest is due to larger size, higher revolutions per minute, better breathing and manifolding, and other design improvements. Further, in heavy-duty vehicles (trucks and buses) the actual gain is only about 70 per cent of the theoretical, and in the passenger car about 40 per cent.

In view of the foregoing, the general view is that there will be a moderate increase of compression ratio and octane rating

TABLE 1 GAIN IN EFFICIENCY BY RAISING COMPRESSION RATIO ONE NUMBER

Change of ratio	4:5	5:6	6:7	7:8	8:9
Theoretical full throttle	14.8	9.3	6.2	4.4	3.0
Heavy duty	10.1	6.5	4.3	3.1	2.1
Passenger car	5.8	3.7	2.5	1.8	1.2

NOTE: Obtained only if rear axle ratio is changed or engine size reduced, to keep peak horsepower constant.

TABLE 2 GAIN IN POWER BY RAISING COMPRESSION RATIO ONE NUMBER

Compression ratio	4:5	5:6	6:7	7:8	8:9
Full throttle, 13:1 mixture	14.4	8.8	7.0	5.6	4.9

Presented at the Mechanical Engineering Conference, Pittsburgh, Pa., April 22, 1947.

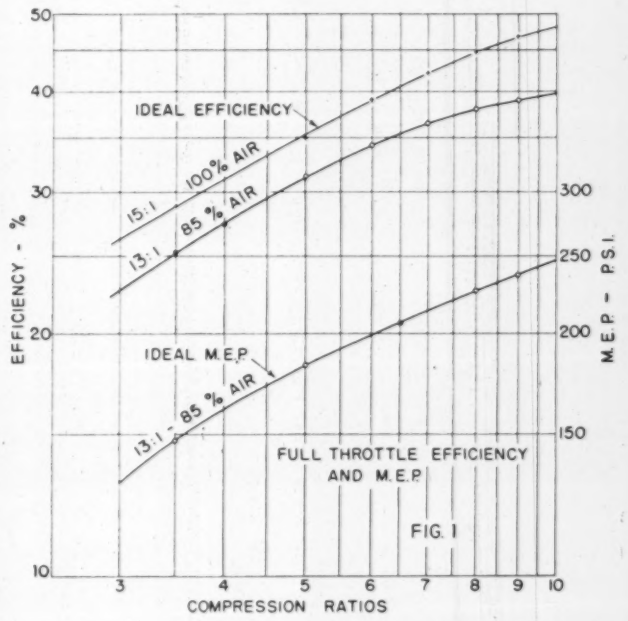

FIG. 1 FULL THROTTLE EFFICIENCY AND MEAN EFFECTIVE PRESSURE

of gasoline. The octane ratings now used are based upon the research method, a C.F.R. rating, and are from 6 to 10 numbers higher than the motor method, or A.S.T.M. rating formerly employed. Before the war, premium gasoline was 81–83 motor method; now the advance has reached 82–85 motor method, corresponding to 89–93 research method. So by the mere substitution of one test method for another, most of the skip toward 100-octane gasoline has been accomplished. The concensus of opinion collected by A. T. Colwell was that 8:1 would likely be the highest compression ratio for several years. What is at present the most interesting and valuable improvement now going on is tailoring the gasoline to suit the engine. It is now known that a single octane number does not fully define the quality of gasoline, since the engine octane demand varies with speed. As a consequence, in two gasolines of identical octane number, one may be knock-free at high speed, not at low; the other the reverse. We now run road ratings at speeds from 10 to 70 mph and get the characteristic octane rating of the gasoline with speed. When this has been done, the single octane number is a sufficient criterion of the general level of the octane value for control purposes. Fig. 2 shows a typical curve.

Other qualities of gasoline, much less publicized, are important. Volatility determines the engine behavior considerably, and has almost as much influence on driver good temper as octane value. The 10 per cent evaporation temperature

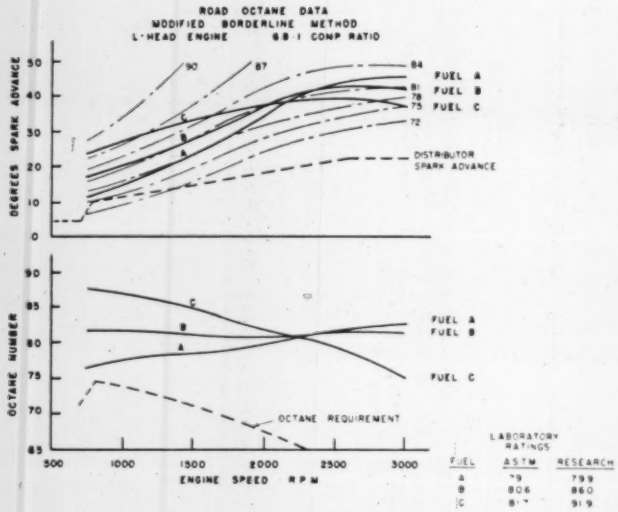

FIG. 2 ROAD OCTANE DATA

generally accounts for ease of starting; the 50 per cent point for quick warm-up; the 90 per cent point, to a lesser degree for warm-up and for engine-fouling deposits. Gasolines have actually been on the market that started instantly in cold weather but the engine immediately died and several starts were necessary. This means the 10 per cent point was all right, 50 per cent point too high. The reverse has also been true. Fig. 3 shows the general range.

It is plain that the refiner has a rather difficult task in many cases, since he has been chiefly refining to get high natural octane value to keep down the ethyl additions. However, he must simultaneously control volatility, and the two do not always travel together in refining. So a compromise must be adopted, always keeping cost of manufacture in mind.

The "cat-cracking" processes now much in use yield higher natural octane value, but sometimes less stable materials. Therefore it has been necessary in some cases to change refining methods, or add inhibitors to prevent gum formation.

We all like to avoid adding tetraethyl-lead (TEL) to get octane value, as it is now established that the lead salts act to increase deposits on valves and give rise also to pitting, together with deposits elsewhere, as in the ring belt, and sometimes encourage sludge in the crankcase. The use of TEL has always been justified, since up to the present it has been the cheapest method of getting octane rating. But the lead susceptibility of gasolines is such that increasing amounts of lead produce less and less improvement in octane value, whereas the troublesome effects increase.

As matters stand, we have gasolines that are ample in octane value for all the present cars, new and old, and they are improving in volatility characteristics and stability.

The old argument of carburetion versus injection still goes on, with about the same conclusions. Injection can get rid of distribution troubles, which are usually present in carburetor-plus-manifold combinations. Injection means leaner average mixture, lower octane requirement, and better economy, theoretically. This is not, however, always attained in current commercial use.

The main obstacles are cost and maintenance; the injector system must be precision-made and is therefore quite vulnerable to poor lubrication and dirt; Diesel injector experience is a good proof. But the major item by far is first cost; until the injector system is about as cheap as a carburetor system, it will not see much application to gasoline engines.

DIESEL FUELS AND FUEL OILS

Diesel fuels and fuel oils are in general a by-product of gasoline refining. Since cat-cracking is considerably employed, we must accept cat-cracked material in these fuels also, and the advantages and disadvantages are of much the same kind. The advantage is higher Btu per gallon, and there may easily be advantages in ignitibility. The disadvantage will be due chiefly to lower stability, and has given rise to deposits in storage tanks and clogged filters in the earlier blends brought out. Some trouble can also be seen in deposits on the burner and boiler, but it should be stressed that cat-cracked materials do not need to be any less stable than straight-run stock. The refining operation can be readjusted to make highly stable fractions, and some of the latest fuel-oil blends containing 50 per cent cat-cracked material show as good all-round performance as 100 per cent straight-run. All of these conditions had to be found, as little or nothing was known of the peculiarities of cat-cracked stock when it was first produced. Many hundreds of thousands of dollars have been spent in research on the new fuel oils since V-J Day. For example, the author's company has a $50,000 laboratory and a crew of eight working continuously on household fuel-oil alone. Fig. 4 shows the kind of data obtained on fuel oil.

In all probability we shall find that much the same properties which are required to make a Diesel fuel good are required for a fuel oil. We are beginning to establish correlations between cold-starting and smoke; and such criteria of Diesel fuel as cetane number, cetane index, Diesel index, aniline point, acid absorption, acid flocculation, and the English test for smoke point may be of value for the performance of fuel oil. Carbon-hydrogen correlation also looks promising.

It is to be noted that there is a distinction between ignitibility and burnability. Ignitibility is probably chiefly controlled by front-end volatility, but burnability involves the character of the combustion.

Straight-run oils, chiefly paraffinic and naphthenic molecules, appear to burn directly to carbon dioxide and water vapor, but cat-cracked oils, containing high olefins and aromatics, appear to burn by a kind of two-stage process. First there occurs a partial oxidation of some of the material to resinous or gummy material; a kind of cracking with oxidation. These intermediate compounds appear to have a high ignition point, and if the furnace parts or refractories are not hot enough to ignite

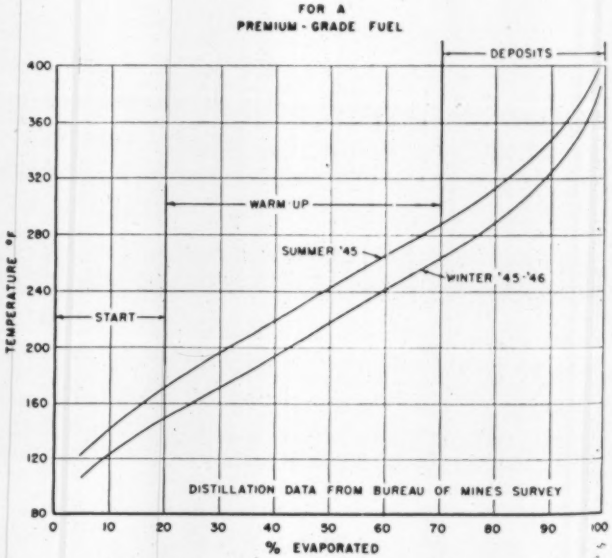

FIG. 3 TYPICAL DISTILLATION DATA

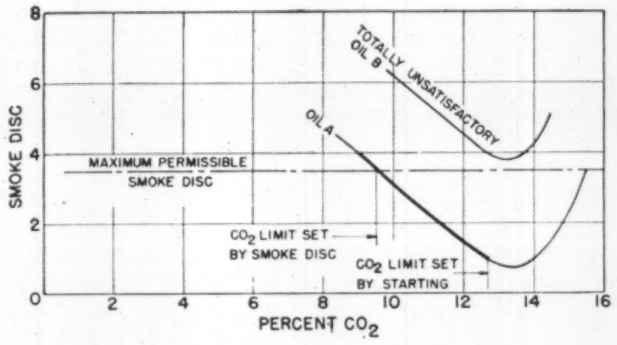

FIG. 4 ROTARY-WALL-FLAME BURNER; SMOKE DISK VERSUS PER CENT CO_2
(Constant fuel-oil flow and draft.)

them, they will deposit as gum or resin, fouling the burner parts or shorting the starting electrodes. The second stage of combustion extends, so to speak, from the first when these by-products are in turn ignited.

The rotary-wall-flame type of burner is likely to be sensitive to these fuels, as there is an area, which is hot and no combustion occurs, between the fan (where oil and air enter the combustion chamber) and the point of flame production. This space is not hot enough to complete the combustion of the gummy by-products, but is hot enough to cause their formation.

Gun-type burners, which complete the combustion in a refractory chamber right at the point of entry, are not sensitive to these fuels. The combustion chamber is very hot, combustion is largely completed before much heat absorption occurs, and the flame is within a few inches of the atomizer nozzle. This fortunate condition should not be taken to mean the gun types are generally superior to the rotary-wall-flame types; they have other troubles.

LUBRICANTS

It must be recognized that, in general, the design of a bearing has much more controlling influence on successful operation than any oil that may be used in it. The proof was plain in the early days of this century when bearings were more generally lower load and speed. For example, reciprocating engines and compressors, and later the steam turbine, with bearing loads under 200 psi, ran very well on oils we should now consider quite inferior, the oil remaining in use for periods of 3 to 5 years, prime movers in many cases operating a total of 30,000 hr before oil change.

In the modern steam turbine we have very moderate inlet and bearing temperatures, not often above 200 F, substantially no contamination, continuous filtration and centrifuging. In this case the use of oxidation inhibitors has greatly increased the oxidation life of the oil. But the internal-combustion engine created much more trying conditions. Much higher temperatures are prevalent, from a crankcase temperature of 240 F to 280 F, up to piston temperatures of 400 F or more. Moreover, some of the oil on the cylinder wall is subjected to flame temperature, and all of it is exposed to combustion by-products.

Bearing in mind that the chemical rate of breakdown doubles every 20-deg F rise in operating temperature, the usual safe life of 60 to 100 hours in automotive engines is not too surprising. Contributing to the breakdown is the contamination from water containing sulphur compounds, gum and tetraethyl-lead by-products. These come from the fuel. Road dirt through the air cleaner even adds to the difficulties of proper lubrication, as it promotes rapid destruction of conditioned rubbing surfaces by way of scuffing.

A year or so prior to the war, we developed methods of calculating not only the performance of bearings, but the performance of a whole engine-lubricating system. Since the oil is generally the chief means of removing heat from lubricated parts, the flow over each bearing is obviously of major importance.

Starting with Reynolds, the work of Michell, Kingsbury, Howarth, Needs, Dennison, and others has permitted a fair rational calculation of bearing load capacity. The cooling requirement mentioned is not the only reason for controlled and known flow; the bearing conditions, particularly mean viscosity, are also directly affected by flow.

We have been able to compute the flows to each bearing in eight and twelve-cylinder engines within 5 per cent of the measured flow in operation. By this means we have found and corrected the cause of puzzling bearing failures. Such a method is an exceedingly valuable tool in design, to avoid costly corrections afterward.[6]

When babbitt was the major bearing material, we never heard of bearing corrosion, but since loads have increased beyond the fatigue resistance of babbitt, the newer materials have brought with them the corrosion problem. Copper lead and cadmium silver are two materials of higher fatigue resistance, but are very subject to corrosion. Since the corrosion is largely caused by organic acids developed in the oil by oxidation, the cure is in the form of antioxidation additives; these compounded oils are available. Figs. 5 and 6 show the action of organic acids on lead in copper-lead bearings. Figs. 7 and 8 show initial and final stages of fatigue failure.

The 2-104B oils developed for Army use during the war were designed to work in both gasoline and Diesel engines, to avoid bearing corrosion and keep the engine, particularly the ring belt, clean. These oils, containing both corrosion inhibitor and detergent, proved successful in keeping the engine, especially the ring belt, cleaner and they are now used commercially for severe truck and bus service, being known as heavy-duty oils. They will not cure deposits caused by the fuel or winter sludge. No oil at present will do much to these kinds of deposits.

For lighter commercial-truck service and passenger-car operation, a mild inhibited class of oil is preferred, known as "premium."

The designers in their effort for more performance from smaller and lighter engines, may raise the severity of passenger-car engines in the next few years, so that they need more highly compounded oil.

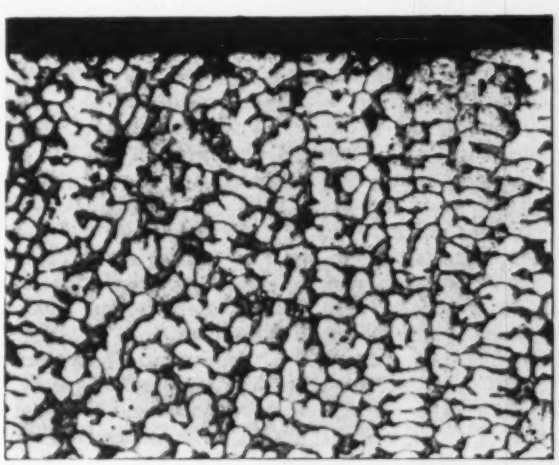

FIG. 5 AN UNCORRODED COPPER-LEAD BEARING
(The lead, the gray structure, extends to the surface of the bearing.)

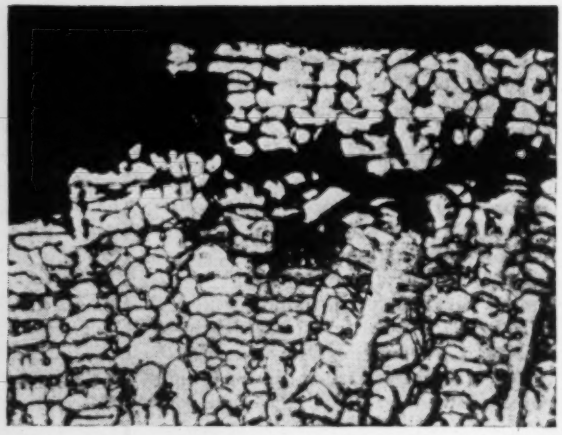

FIG. 6 CORRODED BEARING SHOWING LARGE VOIDS WHERE LEAD HAS BEEN REMOVED

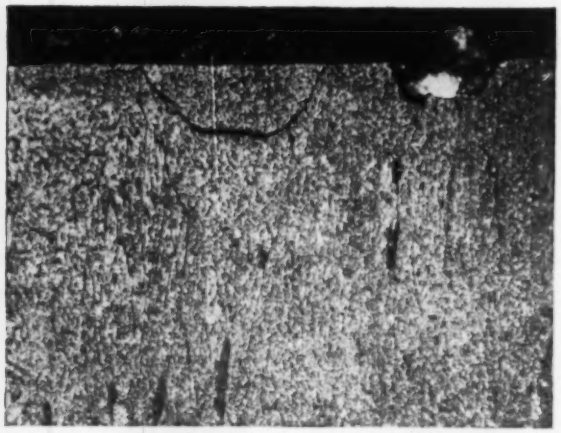

FIG. 7 PHOTOMICROGRAPH OF CROSS SECTION OF MAIN BEARING SHELL NOT CORRODED
(Fatigue breakdown begun.)

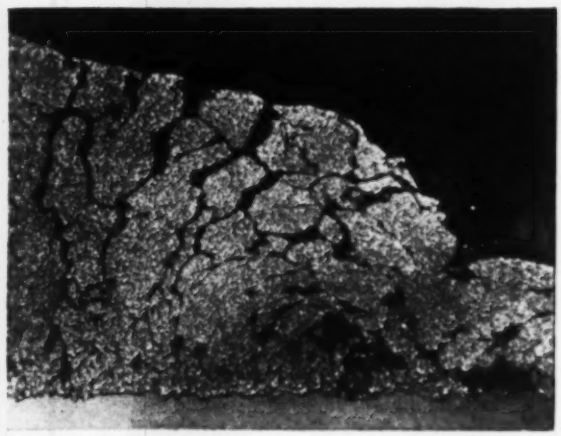

FIG. 8 PHOTOMICROGRAPH OF BEARING FROM SAME ENGINE AS THAT OF FIG. 7
(Complete fatigue failure.)

Silver bearings have become prominent through the aviation industry; this material has the highest fatigue strength of any and is as corrosion-free as high-tin babbitt. In other respects silver is not good, having low conformability and embeddability, and poor seizure characteristics when dirt is present. However, an overplate of lead or lead-indium converts it into a satisfactory bearing, quite suitable for heavy-duty service.

We shall probably see a considerable increase in the use of aluminum-alloy bearings, since these have high fatigue strength, better than copper-lead, and appear to be short only on embeddability. Originally developed by Rolls-Royce, these alloys have been subject to considerable research and offer a very desirable group of qualities. Since tin will not be readily available for years, the high-lead babbitts are likely to replace high-tin babbitt permanently for those bearings requiring only low fatigue strength. Aluminum alloys will probably replace copper-lead and cadmium alloys.

PROPERTIES REQUIRED OF LUBRICANTS

In hydrodynamic, or perfect-film lubrication, the two important physical properties are viscosity and specific heat. The specific heat is of interest for cooling, but since its value varies only from about 0.50 to 0.55 in all lubricating oils, there is no point in using it as a criterion of value. Cooling must be provided by quantity of flow through the bearing.

From consideration of the formulas for load capacity, it would be useful if we could find a liquid the viscosity of which did not vary with temperature. No such liquid suitable for lubrication is known to exist, and none is likely to be found. However, the variation of viscosity with temperature, specified arbitrarily by viscosity index, has been improved of late years. We still have plenty of oils, usually from the naphthenic crudes, with viscosity indexes (V.I.) of 30 to 65, but all the better-grade oils are up around 95 to 105. For cases where temperature variation in operation is wide, these oils are essential; for example, the variation of viscosity even with these high-grade oils is 40:1 between room temperature and crankcase temperature in a high-power aviation engine.

Many oils are now made with viscosity-index improvers but sometimes the experience with them is disappointing. Cases have been noted with severe duty and agitation, as in the recoil cylinder of a gun, where the additive molecules break down and the viscosity-index improvement is lost.

The new synthetics can be made of very high V.I., 150 and better, and these will doubtless be employed to improve petroleum-oil viscosity index, but it should be noted that the synthetics have shown deficiency in some properties such as oiliness. No doubt suitable additions could correct the lack. The cost is at present about 3 times that of high-grade petroleum oils. Therefore, until this situation is improved, we shall not see much synthetic oil in use except for moderate blends, and such cases as aviation hydraulic systems where temperature varies from —60 to +150 F, and the cost of the liquid is not important.

Corrosion of copper-lead and cadmium-alloy bearings has been eliminated by the use of oxidation inhibitors. Where temperatures are not severe, ordinary uncompounded oils will work, but in general the corrodible bearing alloys are used in relatively severe duty and need the compounded oils.

Detergency is needed for Diesel ring belts and for general engine cleanliness in both heavy-duty gasoline and Diesel engines. This property is also desirable for aviation engines, although the Armed Forces have consistently refused compounded oils for aviation up to now. Detergency agents will not, as stated previously, have much effect on deposits caused by gasoline or on winter sludge. However, it must be said that

(*Continued on page 605*)

Aircraft TURBOJET *and* GAS-TURBINE ENGINE STARTER *Systems*

By A. G. BARDWELL, JR.[1]

ENGINEER, STANLEY ENGINEERING COMPANY, MUSCATINE, IOWA

INTRODUCTION

STARTER systems for aircraft engines are no longer in the category which will permit providing only a slightly larger starter and battery for an increase in the size of the engine. At the present time it appears that an internal-combustion-engine starter and a solid-propellant-turbine starter may provide starter systems which will be satisfactory for existing turbojet and gas-turbine engines. However, the starting requirements of future engines may be of such magnitude as to render a completely self-contained air-borne starter system undesirable or impractical as a result not only of the complexity of the system but also of the excessive weights encountered. The problem of providing a lightweight, compact, and reliable starter system has become one which requires a completely new and vigorous approach and which must not be hindered by requirements imposed as a result of the fond memories of the barnstorming era.

Starting systems for combustion-type engines are generally considered to include (1) the initial ignition system, (2) the initial fuel-supply system, (3) the initial lubrication system, as well as (4) the device or system which imparts motion to the rotative parts and maintains the motion until the engine is capable of self-sustained operation. Although all four of the afore-mentioned are of prime importance, this presentation will deal only with the latter, hereinafter referred to as the starter system, as it relates to aircraft turbojet and gas-turbine engines.

A turbojet engine is defined as a turbine-type engine which is designed to deliver only enough rotative power necessary to drive the compressor and various accessories such as fuel pumps, oil pumps, generators, etc. The remainder of the power is delivered in the form of pure thrust power.

A gas-turbine engine is defined as a turbine-type engine which is designed to provide rotative power necessary to drive the compressor, various accessories such as fuel pumps, oil pumps, generators, etc., as well as a propeller. The remainder of the power developed is delivered in the form of pure thrust power.

STARTER-SYSTEM REQUIREMENTS AND EXISTING SYSTEMS

The gas-turbine engine presents the greatest power requirement in starting because of that power necessary to rotate the propeller at high speed, as illustrated in Fig. 1. It is possible that this would be lessened with a satisfactory declutching arrangement between the engine and propeller. However, inasmuch as no system has been developed to date which will economically, with regard to weight and power, and satisfactorily accomplish this, the possible use of such a system will not be considered in this presentation.

Hence, the starter system must provide sufficient power (1) to overcome the inherent mechanical-friction losses of the engine, (2) to accelerate the rotating members of the engine in a short period of time to the desired speeds, and (3) to operate the compressor at a speed and over an adequate period of time which will provide adequate air-flow conditions necessary to obtain satisfactory ignition, burning, and turbine temperature.

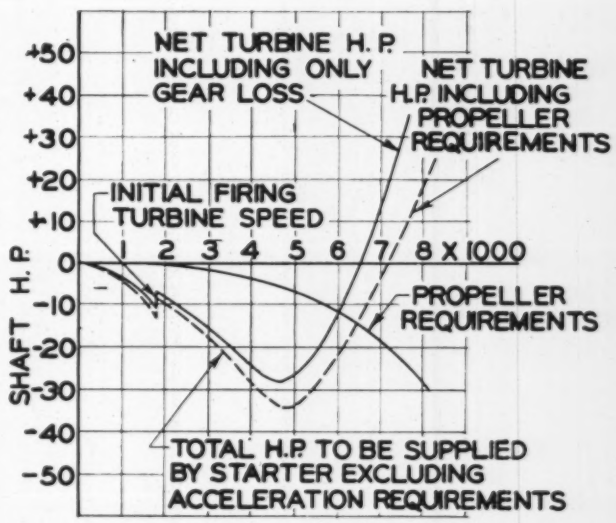

FIG. 1 TYPICAL GAS-TURBINE STARTING-POWER REQUIREMENTS

Other than that necessary for initial breakaway, the inherent mechanical-friction losses account for a relatively small portion of the starter power necessary.

The power necessary to accelerate the rotating members to the desired speed in a predetermined period of time accounts for a large portion of the starter power necessary. Although a maximum starting time has not been specified, certain tactical operations and applications make a 30-sec start very desirable and a 60-sec start the maximum permissible. The practical limitations on the starting time will be subsequently discussed.

The power necessary to operate the compressor at a speed which will provide adequate air-flow conditions necessary to obtain satisfactory ignition, burning, and turbine temperature accounts for the largest portion of the starter power necessary. This portion, however, is dependent upon the starting time inasmuch as the power necessary to accelerate a mass is inversely proportional to the time required for the acceleration assuming a constant acceleration

$$P = K \cdot \frac{1}{t} \cdot I \cdot a$$

where

P = power necessary to accelerate a mass
t = time necessary to accelerate a mass
I = moment of inertia of mass to be accelerated
a = acceleration
K = constant

[1] Formerly Captain, U. S. A., Electrical Branch, Equipment Laboratory, Engineering Division, Air Matériel Command, Dayton, Ohio.

Contributed by the American Rocket Society, the Oil and Gas Power Division, and the Aviation Division and presented at the Annual Meeting, New York, N. Y., December 2–6, 1946, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

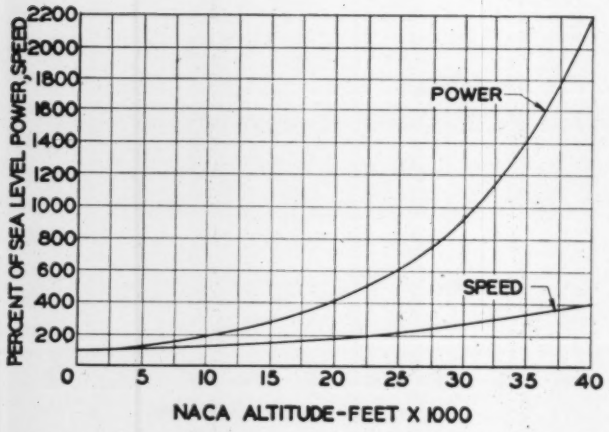

FIG. 2 POWER AND SPEED CHARACTERISTICS OF AN IDEAL COMPRESSOR TO PROVIDE A GIVEN AIR FLOW NEGLECTING AIR-RAM EFFECT

Conventional reciprocating types of aircraft engines generally employ the 28-v d-c direct-cranking starters designed to operate at a starter terminal voltage of 15 to 18 v direct current. (The voltage of 15 to 18 v has been found to be the starter terminal voltage generally obtained from standard 24-v aircraft batteries during heavy load conditions imposed by the starter system.) Other starters, such as the inertia starters, the combination inertia - direct cranking starters, the cartridge starters, the air starters and many others, have been used but are generally being replaced by the direct-cranking starters. The largest such starter now being used is rated at approximately 5 hp and weighs approximately 28 lb.

Direct-cranking electric starters and combination starter-generators are being used on turbojet engines at the present time. The General Electric types I-40 and TG-180 and the Westinghouse type 24 turbojet engines require approximately a 10-hp unit. These starters and combination starter-generators are designed to operate on a terminal voltage of from 12 to 17 direct current, which is obtained from a 24-volt high-rate discharge battery under load.

In order to be entirely self-contained in the aircraft, this type of starter system weighs approximately 140 lb. Ten pounds of this weight is assumed to be chargeable to the necessary cable. Approximately 30 lb of this weight is chargeable to the starter. However, in the case of the combination starter-generator which is used on the General Electric TG-180 turbojet engine, this may be reduced by as much as 15 lb as a result of the weight-saving accomplished by combining the starter and generator into a single unit. Approximately 100 lb of the battery weight is assumed to be chargeable to the starter system. Although the total weight of the battery in the aircraft electric system is 150 lb, it is assumed that a battery weighing 50 lb will be necessary for electric-system stability.

Equivalent German turbojet engines were found to be equipped with the Riedel reciprocating-type internal-combustion-engine starter weighing approximately 50 lb. However, this type of system provides starting power only at sea-level conditions and lengthens the starting time by approximately 4 times including warm-up time necessary for the starter. Development of a larger and more highly automatic unit has been initiated by the Army Air Forces in order to study in greater detail the advantages and disadvantages of this type of starter system. It is anticipated that a starter system weighing approximately 85 lb may be obtained which will produce sea-level starts comparable to the present 28-v d-c electric system using high-rate discharge batteries.

At the present time, starter systems are required to be capable of starting turbojet and gas-turbine engines under any condition including restarts at altitude. This requirement is of no consequence when considering gas-turbine engines, inasmuch as the windmilling effect of the propeller will supply sufficient power to obtain a start. However, this requirement may potentially be of utmost importance and magnitude for turbojet engines as is indicated in Fig. 2, which is obtained by making the obviously false assumption that no effect will be derived from the ram effect of the forward motion of the airplane. Other assumptions that were made in order to simplify the calculations are (1) that a given weight of air flow through the compressor is necessary for starting; (2) that the power demand necessary to obtain this given weight of air flow represents the maximum requirements; (3) that no work will be realized from the expansion of the air through the turbine prior to reaching the compressor speed where the required weight of air flow occurs; (4) that the power required to drive a compressor varies directly with the cube of the speed of the compressor, inversely with the absolute temperature of the intake air, and directly with the density of the intake air

$$P = K \cdot N^3 \cdot \frac{1}{T} \cdot p$$

where

P = power required to drive compressor
N = speed of compressor
T = absolute temperature of air at inlet
p = density of air at inlet
K = constant

The ram effect of the forward motion of the aircraft upon the starting characteristics of the turbojet engine is at the present time only partially known. However, this ram effect upon the windmilling speed of the engine is shown in Fig. 3, based on

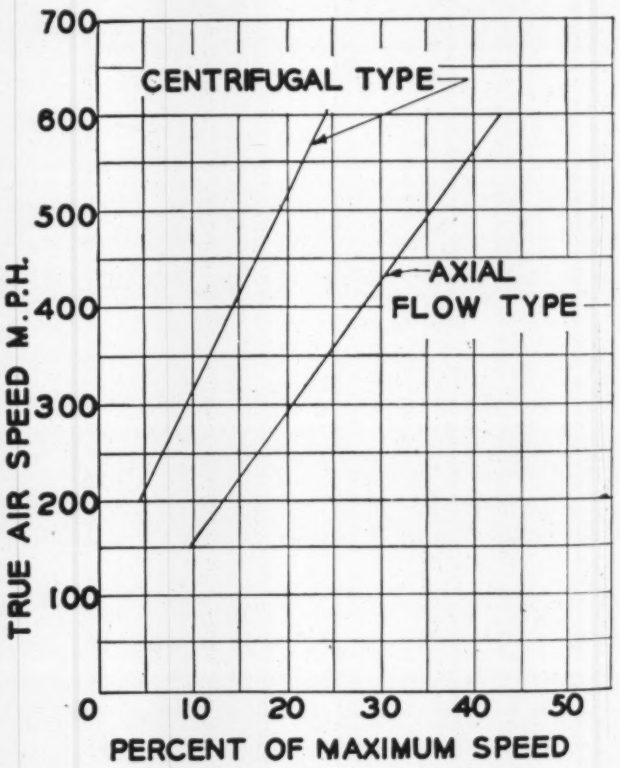

FIG. 3 WINDMILLING CHARACTERISTICS OF TURBOJET ENGINES HAVING AXIAL-FLOW AND CENTRIFUGAL-TYPE COMPRESSORS

N.A.C.A. test data and has been found to be independent of the atmospheric-pressure altitude.

The necessity of providing a given weight of air flow through the compressor is by no means the only major influencing factor. Among other major factors are the ignition characteristics and the burner or combustion-chamber characteristics. Investigations are being conducted at the present time to determine the mutual effect of these three factors on the altitude starting characteristics. If these investigations reveal that the starter assistance in flight conditions is unnecessary, a weight saving of approximately 55 lb may be realized immediately by the use of the reciprocating-type internal-combustion starter engine.

As the size of the turbojet engines and, particularly, gas-turbine engines increases, the required starter power increases at a much greater rate than that for conventional reciprocating-type aircraft engines.

For example, a starter system for the General Electric type TG-100 gas-turbine engine may be required to deliver approximately 70 hp maximum in order to obtain a start in 60 sec; whereas a starter for an engine rated at approximately twice the output may require a starter to deliver up to 250 hp. In comparison, increasing a reciprocating-type aircraft-engine displacement by a factor of 2 increases the starting power required by a factor of approximately $1^1/_2$. Thus the largest starter for a reciprocating-type aircraft engine is not anticipated to be larger than 10 hp; whereas it is anticipated that a starter capable of delivering up to 1000 hp may be necessary for gas-turbine engines.

Heretofore, the time necessary to start aircraft engines has not been of major importance inasmuch as a short starting time does not add materially to the flexibility of aircraft equipped with conventional reciprocating engines because an engine warm-up period is required. However, aircraft equipped with turbojet and gas-turbine engines may take off at such time as the desired engine speed has been attained. Furthermore, the taxiing of such aircraft is undesirable because of the excessive fuel consumption encountered. This feature makes it very desirable to tow such aircraft to the take-off point prior to starting, which in turn makes rapid starting very desirable if not imperative. However, practical limits to the time necessary to start turbojet and gas-turbine engines must be determined. Fig. 4 presents an indication of the rate at which the starter power increases with a decrease in starting time. The data for this curve were derived from the typical gas-turbine starting requirements, Fig. 1, and an assumed starter torque-speed characteristic shown in Fig. 5, rating the starter at maximum speed. The moment of inertia of all the rotating parts with respect to the turbine shaft was assumed to be 150 lb-ft^2.

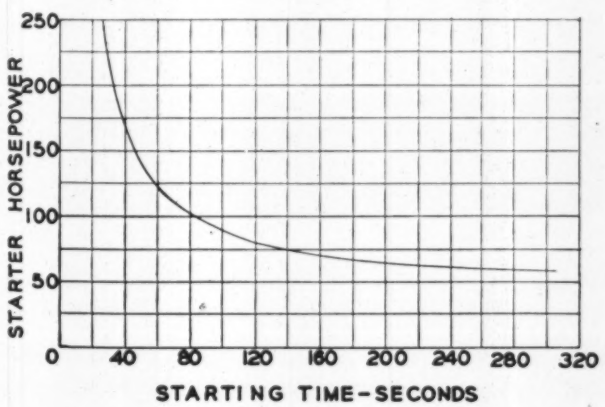

FIG. 4 INFLUENCE OF STARTING TIME ON STARTER POWER, ASSUMING TYPICAL STARTING REQUIREMENTS, FIG. 1, AND STARTER TORQUE - SPEED CHARACTERISTICS, FIG. 5

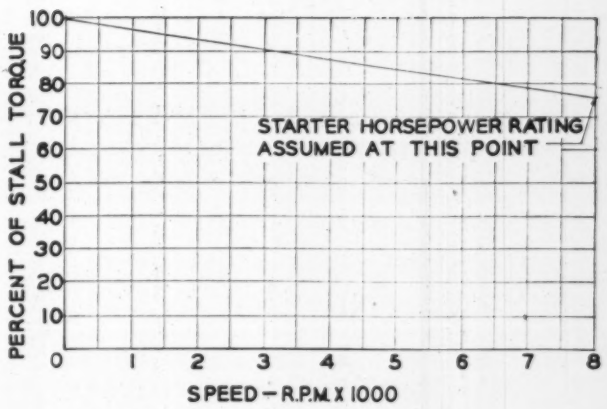

FIG. 5 ASSUMED TORQUE SPEED CHARACTERISTICS OF STARTER

FUTURE STARTER SYSTEMS

Self-Contained Systems. To meet the requirement of larger starter systems, a small turbine starter mounted directly on the engine and powered by a solid propellant contained in a cartridge is being developed. It is anticipated that the unit will weigh approximately 115 lb including the propellant necessary to start a gas-turbine engine in 30 sec. The weight of the propellant is approximately 30 lb which results in an engine mounted air-borne weight of approximately 85 lb. Although this system offers many advantages, particularly in a large weight saving, it is not anticipated that the most desirable starter system will result from applications of this type. Many inherent disadvantages, such as safety in handling, storing, and using, operational reliability, special supply problems, etc., may prove of such consequence as to render such a system entirely impractical at the present time. However, if investigation relative to the starting power required at altitude reveals that a large amount of power may be required, it may become necessary to accept these disadvantages for the present time and attempt to overcome them in the future.

There is also under development a starter system which will employ the power available from an air-borne auxiliary power plant. Such a unit will have as its prime function the supply of electric power necessary for operation of the aircraft. Therefore, during the starting period the entire capacity of the auxiliary power plant is available. At the present time, the hydraulically transmitted system being developed appears to yield an economical result. It is anticipated that such a system may be installed at a weight cost of less than 50 lb per aircraft engine based upon a 25 to 30-hp starting demand.

Considerable thought has been given to the possibility of using the excess power available at sea level from turboalternator units currently under development. Such a unit, which is designed to be capable of delivering approximately 100 hp at 40,000 ft altitude, potentially will be capable of delivering in excess of 400 hp at sea level, all of which may be considered to be available for starting. It appears that a small gas-turbine starter mounted on the aircraft engine will provide the most satisfactory system. The power available from the turboalternator unit may be transmitted to the starter turbine by (1) the further expansion of the exhaust gases through the starter turbine, (2) bleeding the excess air available from the compressor and utilizing the exhaust from the turboalternator unit regeneratively. It is anticipated that such a system rated at 400 to 500

hp will impose a starter-system weight of less than 50 lb per engine on the aircraft weight.

As the size of the gas-turbine engines increases, and as the starter-power requirements correspondingly increase, it is anticipated that it may not be practical to provide aircraft with self-contained starter systems. The requirement of providing self-contained starter systems appears to be motivated by the memory of forced landings in pastures, on highways, and on emergency-landing strips. It should be realized, however, that future aircraft which will be powered by large gas-turbine engines having high starting requirements will not be capable of landing successfully or taking off under the afore-mentioned conditions. For this reason, external or ground-powered starter systems are being investigated.

Ground-Powered Systems. Under consideration as a ground powered starter system is a mechanically transmitted system. This system may result in mounting a reciprocating-type aircraft engine on a portable device, permitting the unit to be taken to a convenient point near the engine nacelle where a mechanical connection may be made to the aircraft gas-turbine engine to accomplish the start. The hazards to personnel as well as equipment that are inherent with high-speed, high-torque, flexible drives are the chief objectionable features of the system. However, this system potentially would have wide application with respect to the different sizes of gas-turbine starters, i.e., the same ground unit may be used to start a wide range of gas-turbine-engine sizes. The possibility of using an electric motor, either alternating or direct current, in lieu of the reciprocating-type aircraft engine is also being considered. Such a system would result potentially in a lighter portable unit and in greater reliability. However, initial installation may be considerably more involved inasmuch as permanent features such as a large centrally located power station, fixed outlets, etc., must necessarily be installed.

A hydraulically transmitted system is also under consideration as a ground-powered starter system. This system would provide a hydraulic starter motor on each engine. The hydraulic connection may be made at each nacelle or at a central point on the airframe and controlled by a selector-valve arrangement actuated by the aircraft-engine operator. The source of hydraulic power may be from a pump mounted on a portable device which would permit adequate flexibility on a flight line. If the characteristics of a hydraulic system are found to be most desirable, the features of the central electrical power plant as mentioned in connection with the mechanically transmitted system may be utilized by providing an electric motor to actuate the portable pump-accumulator unit. The use of a central hydraulic power station with convenient outlets on the flight line may potentially be practical if the advantages over the portable pump-accumulator unit would justify such an elaborate installation at well-established bases.

A system utilizing compressed air as a ground-powered starter system is also under consideration. This system would provide a small starter turbine mounted on the gas-turbine engine with appropriate connections to a convenient point on the engine nacelle or airframe. It is anticipated that a liquid fuel would be mixed with the air and burned at a station prior to its expansion through the starter turbine thus obtaining a much larger amount of energy from the air being supplied. In order to limit the volume of the air container and certain related equipment to the greatest possible extent, air pressures of 1000 psi may be employed. The method by which the compressed air is obtained may be by any number of different methods such as a reciprocating-type engine or electric motor, pump, and accumulator mounted on a portable device, or a central power station supplying compressed air to fixed outlets located conveniently on the flight line.

A ground-powered starter system utilizing an electric starter motor mounted on the engine is not being considered inasmuch as the weight of the electric motor will be excessive. It is anticipated that the mechanical, hydraulic, and compressed-air transmission type of group-powered starter systems will all result in approximately the same air-borne starter weight per aircraft engine, i.e., less than 50 lb for a starter system rated at from 400 to 1000 hp.

Investigations are being conducted with regard to the possibility of utilizing special combustion chambers and nozzles acting directly on the main turbine wheel. However, data available at this time indicate that this system is impractical due to the nonuniform thermal stresses which necessarily are imposed on the turbine blades. The use of compressed air without any addition of heat will necessitate large quantities far in excess of the realm of feasibility.

SUMMARY

In summing up, Table 1 presents a weight-power comparison of the several systems under development.

TABLE 1 COMPARISON OF STARTER SYSTEMS

Type of starter system	Approximate rating, hp	Air-borne weight per engine, lb
28-volt d-c electric	10	140
Reciprocating internal-combustion	30	85[a]
Auxiliary power unit with hydraulic drive	30	50[a]
Solid-propellant turbine	250	115[a]
Turboalternator bleed-off	400	50[a]
Ground-powered starter systems	400 to 1000	50[a]

[a] Estimated.

The use of a self-contained electric starter system operating from a 24-volt battery has been very satisfactory in connection with reciprocating-type aircraft engines. However, it is apparent that such a system may be entirely undesirable and unsatisfactory for present and, particularly, future turbojet and gas-turbine engines. The internal-combustion reciprocating starter engine and the solid-propellant turbine starters are potentially a temporary solution and should by no means be considered as an ultimate or final solution. Ground-powered starter systems, as outlined, also represent an interim solution. Thus, the problem of starting aircraft engines has ceased to become one merely of increasing the size of the motor and the capacity of the batteries to meet with an increase in the size of the engine. It requires a completely new and vigorous approach not to be hindered by fond memories and requirements so imposed.

Turbojet Engine

A new turbojet engine, producing a rated thrust up to 5000 lb, has been developed for the Army Air Forces by the Menasco Manufacturing Company, Burbank, Calif. The new engine, designated the XJ-37, is said to develop more power than a Diesel-electric railroad engine in less than one fifth of one per cent of the Diesel's weight.

After six years of secret design, development, and component testing by the manufacturer and Lockheed Aircraft Corporation at Burbank, the completed plant is now undergoing static test runs. The entire project has been sponsored by the Army Air Forces.

The XJ-37 has an extremely small frontal area, facilitating installations in either wing or fuselage with minimum drag of nacelles or inlet ducts. It can be applied either as a pure jet engine or as a turbine with propeller.

It is claimed that the efficient fuel consumption of the new engine guarantees long range and offers a high thermal efficiency.

The ENGINEER *and the* HISTORIAN

By LOUIS MARTIN SEARS

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IT has fallen to the lot of the author to introduce various classes of junior and senior undergraduate engineers to the mysteries of modern European history. In his opening lecture he has found it salutary to remind these youthful followers of Archimedes that a page of history, so easily read but so difficult of comprehension, may cover a solution which has consumed centuries of time and oceans of blood in the attainment. Thus one may reduce to a paragraph or so the 1922 agreement between Ireland and Great Britain, recognizing the Irish Free State, while reserving Northern Ireland to the British Commonwealth, but such a neat condensation gives no recognition to the centuries of bitterness behind it. Also, unhappily, but for the good of these young people's immortal souls, it has seemed appropriate to remind them that only the most illustrious engineers, men like Gorgas and de Lesseps, make the pages of general history, whereas history is replete with the doings of third-rate politicians and a whole raft of people whose work is less constructive than the engineer's. These remarks are introduced so early to persuade the student that possibly the control of nature which he is bent upon establishing, or, at any rate, upon advancing, is of an importance secondary to that of controlling men and nations. Certainly the engineer lacks somewhat of being a well-rounded citizen if he is so absorbed in practical mechanics that he gives no thought to practical politics; if he is so intent upon the conquest of the air that he ignores the conquest of the spirit.

Nor is the fledgling the only engineer who may profit from an occasional attempt to grasp the truth and grasp it whole. The engineer who has relied upon his skills to fashion a new world has recently beheld that world disintegrating like a house of cards. For where was engineering more developed than in defeated Germany? And where was ignorance more abysmal of all the social sciences, more particularly political science, international relations, psychology, and history? The German strove to build a tower of Babel. Nor did he fall far short of this endeavor. What he failed to reckon with was God and man. He was the merest tyro in his understanding of human nature. He did possess a historical technique, but it resulted in a pseudoscientific history that failed to provide him with the deeper lessons of the past.

HISTORY IS ALL-INCLUSIVE

In history is the record of past life, of life in all its phases, and if that record is warped by a total lack of comprehension of men and motives, more particularly of the nobler men and the higher motives which reflect a divine spark that leads man to hate cruelty and meanness, and, at his best, to love justice and mercy, and, like the prophet, Micah, to walk humbly with his God; if that record is warped, I say, by a crass materialism that looks upon things alone as good and ignores their interpenetrating spirit, then history itself misleads, and its lessons are flat, stale, and unprofitable. Thus, history must reckon with a past both great and generous, if it is to provide the counterpoise to men whose daily thought is bounded by material things—in short, to engineers.

I have defined history as the record of past life. Such a definition is obviously all-inclusive. It suggests the famous aphorism of the Roman Emperor, Marcus Aurelius, "*Nihil humani mihi alienum est*"—nothing of human concern is alien to me. But even as Marcus Aurelius, though he lived in pagan antiquity, was a thoroughly sophisticated person, as complete a humanist as any modern, and his philosophy a highly ripened product, so history as here defined is decidedly a modern concept and represents a distinctly evolutionary view of life. Certainly history as viewed in other times and places has represented something far less comprehensive. The annals of a fifth-century monastery may record for an entire year no other item than the raids of the barbarian, the visitation of a pestilence, or the coronation of a king.

Even till quite recent times, the historian could subscribe to Freeman's definition, "History is past politics," politics as construed rather broadly, to be sure. For traditional history has been narrowly political, or military, or ecclesiastical. It has been concerned with major personalities rather than with the masses and their way of living. The great man could be comprehended in biography; the small man was a matter for statistics. With the passing of time and with an acceleration of momentum, history has expanded to include the economic and the social, the psychological, and even the psychiatric interpretation of events, in harmony with man's expanding views in all fields of intellectual awareness, the scientific by no means least.

Indeed, the growth of the historians' concept may be likened to the theologians'. It is a far cry from Jehovah, as a tribal deity, feasting on the blood of goats and rejoicing that the cattle on a thousand hills are His, to the Christian concept of the Fatherhood of God and the Brotherhood of Man. That such a concept is as yet far from being realized is quite beside the point. It is a goal beyond the dreams of primitive man. It confronts man in the atomic age with the alternative of early realization or else complete destruction.

HISTORICAL ENGINEERING

As life and its historical record have grown increasingly complex, so various techniques have evolved sufficiently to deserve their separate recording. Pharmacy, for example, became in the thirteenth century a thing distinct from medicine. From then until the present hour it has been entitled to a specific history of pharmacy. The same may be said of numerous techniques with which engineers are professionally familiar.

The engineer may be concerned with even the prehistoric. No physical remains that man has left are more remarkable than the mounds, mistakenly called Indian, of the Ohio Valley, supreme examples of which are preserved in the Mound State Park, near Anderson, Indiana. These stimulate imagination

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as survivals of a past unguessably remote and of a people totally unknown. Their nature and their purpose alike defy analysis. But their symmetry presupposes a prehistoric knowledge of geometry. Their purpose may conceivably have been military. It can scarcely have been sepulchral, or excavation would reveal the fact. No, the mounds are a great mystery, but if the mystery is ever to be solved, the engineer would seem to hold the key. Thus, the engineer may join hands with the archeologist in pushing the frontiers of our knowledge ever farther toward the past.

In other portions of the world, a Druid mound on Derwent Water or on Salisbury Plain, a trace or two on the Swiss lakes of prehistoric man, a tooth or tusk from a Siberian bog, call men of science, archaeologists for the most part, to a fresh interpretation of the past, to a more vitalized conception of the dignity of man as reflected in an antiquity incredibly remote. Here again the engineer, whatever be his more specific designation, becomes the pioneer in prehistorical research, and an advance agent for a broader humanism, reflecting the totality of man's experience.

THE ENGINEER CHANGES THE WORLD

In military and naval history, the engineer is alike the beneficiary and the interpreter. The development of weapons from the slingshot to the atomic bomb falls within the purview of the engineer. As a military technician, he accounts for the Greek fire of the chemist; and in practical or applied mechanics, he promotes all of the advances from the arquebus to the most modern rifle. Always he is the engineer of war, and the advances in his skills spell success or failure for the one side or the other. For the most part he is unheralded and unsung. The kudos of fame and the historians' acknowledgment falls largely to the politician, more rarely to the statesman. The engineer, as likely as not, never analyzes the results of his achievements or bothers with their deeper implications.

Of the naval engineer, the same is true in equal, possibly in greater, measure, for the influence of sea power upon history, as set forth by Captain, later Admiral, Alfred Thayer Mahan, has become a commonplace of historical interpretation. The war canoe of the aborigine, the trireme of classical antiquity, the high-pooped galleon of the Armada, the low-slung ships of Drake and Gilbert, the swiftly sailing ships of Nelson, the ironclad, the dreadnaught, and finally, the airplane carrier—all are the gifts to war of the marine engineer. His contribution is appalling. Has he read or understood it?

To these developments of land and sea the aeronautical engineer has lately added a factor wholly revolutionary. He has overthrown all previous concepts of geography. Not only has he eliminated time and space—the oceans are no longer a protection—but he has given a new orientation to the nations. In antiquity and for centuries thereafter, the Mediterranean was what its name implied, a middle route for commerce between Western Europe and the Near East and beyond. By the late fifteenth century a new breed of navigators had rounded the Cape of Good Hope for a new path to Cathay, while that supreme adventurer, Christopher Columbus, had made his way to a new hemisphere. Henceforth, the ports of Western Europe facing the Atlantic, chiefly those of England and the Netherlands, replaced their elder rivals, Venice, Genoa, Marseille, and the rest, and the main direction of the voyager was between the old world and the new.

In our own century, the engineers who made the Panama Canal a functioning reality, created a fresh bent toward the southward. Woodrow Wilson, at any rate, foresaw an increased contact between the Atlantic coast of the United States and the west coast of South America as the result of the accomplishments at Panama of engineers, chiefly civil and mechanical. To some extent his anticipations have been realized—a further triumph for the engineer, and a major contribution to our present era.

But these accomplishments, however vast and however revolutionary, pale before the most recent fruits of that American invention, the airplane, which at this very moment is transforming the Arctic Ocean into the greatest of air highways and is bringing Russia and ourselves into a relationship on either side of the Arctic wastes, painfully similar to that relationship which centuries ago marked Rome and Carthage as natural antagonists, and culminated in three Punic Wars wherein Rome eventually triumphed and her rival was obliterated.

These historical parallels are truly painful to reflect upon. They warn us that historically the new geographical propinquity of Russia and ourselves is ominous. They bid us strive for mutual good will, for a world federation on the pattern which the American Constitution foreshadows. They call us to explore every corner of the human spirit for possibly untapped resources of the mind and soul in the creation of a new heaven and a new earth, for by historical standards the old earth is doomed unless political and spiritual conceptions can be brought into play to control the elements unleashed by science.

Until such a day can dawn, the engineer, with his blind devotion to material controls, will hold the lead over the politician, the statesman, and the ecclesiastic. It is only through the dawn of such a day that the age-old conflict between the projectile and the armor plate can conceivably be terminated. Always the one eventually neutralized the other. But in the opinion of those who are informed upon such matters, there neither is nor can be a scientific offset to the atomic bomb. The only conceivable defense against it must be political and spiritual.

ENGINEERING THE ATOM

If, in 1844, the first message sent by telegraph was appropriately enough: "What hath God wrought?", the message of Nagasaki and Hiroshima was: "What hath the engineer wrought?" Certainly the engineer has brought all humanity face to face with the problem of world brotherhood, with a new and spiritualized version of world power or downfall.

These considerations of the engineer as a leader in the new geography (dare I add the new theology?) suggest his function as the resolver of old problems and the projector of new issues whose eventual solution vexes the intellect and conscience of us all. In a very genuine sense, the recognition of his responsibility as an engineer, and still more urgently his responsibility as a citizen toward atomic fission and its uses is the ultimate test of the engineer as a citizen of his own country and the world. Never before has so compelling a problem confronted our race. The engineer has posed it—can he solve it? We must wait and see, but delay may not be long as the time is waxing late.

SCOPE OF ENGINEERING HISTORY

For our present concern, there are some issues of less weight which can be posed with some hope of a solution. For one there is the increasing variety of engineering techniques. The great branches of civil, mechanical, and chemical engineering are very old, with a history dating far into antiquity. In them as in general history, periods of exceptional interest can be discerned, alternating with others where progress is not apparent, or even retrogression may have intervened. For civil engineering this is evident in the history of architecture. Disregarding numerous prehistoric remains, to one or two of which allusion has been made in passing, and for the understanding of which

the skills and labors of the archaeologist must needs be requisitioned, survivals of civil engineering in historic times are rich and varied, and provide not only the student of general history but the specialist in the history of engineering with innumerable examples of the material environment of man's historic past. What is equally important, they stir the imagination of posterity. The great wall of China, the pyramids of Egypt, the ruins of the Parthenon, the Roman Forum, the mass of irrigation ditches in the Tigris-Euphrates Valley, surviving Roman works in France, in England, and beyond the Danube, all these and many more create in the sensitive and the impressionable a fresh respect for the pageantry of life and the accomplishments of man.

Then there is the glory of the Middle Ages, occasionally secular, as in the Cloth Hall at Ypres; more characteristically ecclesiastical, as in Mont St. Michel and Chartres, the Sainte Chapelle, York Minster, or the amazing spire at Salisbury, whose 402 feet of elevation rest upon the principle of the inverted arch, just as so much else of Gothic splendor was dependent upon the flying buttress. To the artist, these remains convey their special meaning. To the general historian, they represent the symbols of their times. For the historian of civil engineering, they minister to a special pride. What obstacles were surmounted by past engineers in their seeking for the absolute in utility and beauty!

If Roman roads yield to the transcontinental highways of America, or to the Autobahn of Hitler, conceived in iniquity but engineered with skill; if no monument of civil engineering in antiquity quite equals the canals at Suez and at Panama, it is but right that so venerable a technique as civil engineering pass on to further triumphs. Its story is a long one. Past and present suggest that it is evolutionary.

Of mechanical engineering, the record is mostly modern. The invention of the wheel was epochal. It advanced immeasurably the progress of those branches of our race which made use of it, in contrast with the Indian who knew it not. Quite literally the wheel was a revolving point in civilization. Also, the Middle Ages provide the historian with examples of the engineer's inventiveness. Too many of these unfortunately reflect an ingenuity in contriving instruments of torture. Inventive talent was warped to a fell purpose by the harshness of the times. But the talent was unquestionably there, and under the peculiar complications that ushered in the industrial revolution, the mechanical engineer came into his own. From 1760 when the revolution was inaugurated, even to our present day, the mechanical engineer has been the great instrument for change in western civilization. The record of his accomplishment lies all about us. To the general historian it is a constant challenge; to the historian of engineering, it should be a prideful revelation.

Auxiliary to mechanical engineering are automotive and aeronautical engineering, each of them so distinctive in their functioning as to merit separate treatment by the historian. They are as deserving of an independent record as electrical engineering, no older than Benjamin Franklin, in reality no older than the incandescent bulb of Thomas Alva Edison. Progress in the scientific age calls indeed for an increasing subdivision of the record to comply with the requirements of new engineering skills which have attained their individual maturity. Radar, for example, so amazing in its brief existence, will soon deserve, if it does not deserve already, an independent record. One anticipates the same of other skills, as yet not even contemplated.

As for chemical engineering, third among the techniques listed in this current phase of our discussion, superimposed upon accomplishments in various professional directions, the release of atomic energy is so stupendous an achievement as to promise that this may be the chief field of engineering in the future, or else that it may terminate engineering and all other interests, in the downfall of the West. It holds over our entire civilization the pledge or threat, so familiar to the German, of *Weltmacht oder Niedergang*.

TECHNIQUES FOR RECORDING ENGINEERING HISTORY

In a field of inquiry so deserving the best endeavors of historians, who, it may be asked, will keep the record straight? Should he be a professional historian, or should he be an engineer? Should he be an individual at all? Is not the material at hand so vast as to defy the competence of individuals and to require co-operative scholarship? Engineers long have been familiar with co-operative projects for the advancement of scientific knowledge. The research staffs of numerous corporations are a case in point. Historians, likewise, are frequently co-operative. Projects like the Dictionary of National Biography, the Dictionary of American Biography, and the Dictionary of American History, are known to the public as well as to the profession.

It is unimaginable that the historian should comprehend at all adequately the enormous growth of scientific and engineering techniques. Far easier would it be for the engineer to master the historian's methodology. On the other hand, the historian is trained to a breadth of vision, that is, unless he is the veriest hack, whereby he perceives as on a chessboard the most divergent elements falling into place. Perspective is indeed a vital aspect of the historian's craft. The engineer, untrained in such perspective, might miss the large significance of matters which he fully understood in detail.

Quite probably the record not so much of things now past, but the infinitely complex record of things as yet to come, will enlist the engineer and the historian in a joint partnership for the transmission to posterity of the experience of the race. Such a partnership would be a fairly equal one, for the historian from Herodotus, with his record of Egyptian methods of embalming, to Henry Adams courageously balancing the relative influence upon mankind of the Virgin and the Dynamo, the historian, I say, should not be minimized as a factor in interpretation. When he miscalculates too badly, either through ignorance or under political compulsion, and gives his fellow citizens an erroneous impression of their own past and their neighbors', the historian can be a major trouble breeder, who reinforces the ideologies that lead to war even as the engineer is busy with new instruments for rendering the war destructive.

In short, the very perspective to which the historian is trained, should convince him of his partnership with the engineer, should reveal to him the composite whole, the social interplay, the orchestra of talents, in which the engineer and the historian alike have instruments to play. For in those realms beyond the present, those realms defined in Bible lore as "My Father's House," wherein the many mansions lie, there is room for engineers and all artificers of the good life, room even for historians, who do not exactly toil, neither do they spin, but who sing the deeds of others with a right good will.

The foregoing are but a few of the generalizations which occur to the historian when he contemplates the engineer. More could, of course, be added, and perhaps one or two suggestions may be permitted now. Thus the engineer may obviously be considered as a subject for biography. Leonardo da Vinci, link between technology and art, would fall within such purview along with Michelangelo. Or a patriotic note is sounded in the contemplation of George Washington, the engineer. The occasional engineer from the Earl of Bridgewater to George Westinghouse is the natural theme for the biographer.

As an ancillary theme, the engineer may be a controversial figure. Storms raged about Ferdinand de Lesseps as only re-

cently they raged over David Lilienthal. Assuredly the engineer over whom the battle of the dams was fought—Boulder versus Hoover—will long retain a controversial flavor. Yes, engineers provide their quota of man's interest in his fellow man. Creators in their respective fields, they are distinctive personalities and avoid instinctively the common mold; for the engineer is very much a person.

THE RESPONSIBILITY OF THE ENGINEER

Whether as creator of the material world in which the life of man has been unfolding, or as colorful and interesting personalities who have peopled that same world, the engineer has been the fashioner rather than the interpreter of history. Perhaps he has been concerned too little with the wider implications of his work. At any rate, he even now is threatening to bring it to an end, tossing away like a house of cards the amazing edifice of Western Civilization. If, however, miraculously that edifice is spared and allowed to rise upon foundations of atomic energy, released for man's improvement rather than his overthrow, then the engineer must help increasingly to preserve the record. He must join with the historian in a partnership to which each brings fruitful gifts. The engineer and the historian will either die together—or it may be they will live!

The World the Manager Lives in

(*Continued from page 543*)

markets, cheap power and transportation, plenty of man power, meaning a reservoir of unemployed, and low taxes. He points out how shortsighted it is not to take into account that the effectiveness of the plant will eventually depend upon the people in it and how they feel. He suggests, therefore, that in locating a plant, the primary factors should be such things as a social environment friendly to the industry and its employees, an efficient and liberal school system, provision for comfortable and modern housing within the means of the employees, and recreational facilities.

It is encouraging also to observe the acceptance of the professional industrial-relations director in the councils of top management where, in many cases, he is a vice-president. Progressive social-minded management realizes that it cannot divorce itself from responsibility for the social solidarity of its organization. But it also realizes that in discharging that responsibility it needs the expert advice of the professional industrial-relations director who has high social skill and is thoroughly acquainted with all the known psychological, sociological, and legal factors that are involved in creating a stable industrial organization.

Another encouraging sign is the general awareness of the responsibility of management and of the obligation it accepts for doing its part to prevent economic instability. The report of the International Chamber of Commerce on "Maximum Employment in a Free Society," is a brief but excellent document which analyzes the sources of instability and defines the responsibilities of management and government for minimizing instability.

We live in a cosmos of universal inequality. For reasons inscrutable to us, the Creator has distributed human talent and character on the same bell-shaped curve to which all else in the universe conforms. Fortunately, the number of idiots at the one end of the curve grows less, and the number of men and women of great talent at the other grows greater.

Those leaders at the end of the curve, in whose hands lies the responsibility for industrial management, are alone in their talent—they have no one to whom to pass on their responsibility.

They have the prestige, the privilege, the burden, and the loneliness of command at a time when the decisions they are making will probably affect the whole course of world civilization.

Improving Labor Efficiency in Day-Work Factories

(*Continued from page 572*)

mechanic start from scratch. When the job design nears the production stage, first one operator, then another, and finally a third are pulled in and taught the new method. When all the "bugs" are combed out of this new job, it is moved back onto the "floor" again.

Know Your People. It is surprising how much can be accomplished when two people are perfectly relaxed and see each other's point of view. This is one of the strong arguments for the small plant; the superintendent will get to know and understand all of his people.

If I were a foreman with a tough production job to lick, I believe I would call the group of 2, 5, or 10 people together (I might even take them to lunch with me) for the purpose of (*a*) getting better acquainted, and (*b*) solving a few personal and plant problems. I might start the ball rolling at such a meeting by telling them some of my background, and having them tell me and the group a little of their past history; where they were born and had spent most of their lives, how they had come to work for this company, etc. All of us would become better acquainted than we ever before had been.

Then the session would be devoted to the job problems each may have experienced. Instead of starting this myself, I would save my problem until last. With a notebook in front of me, I would jot down one major source of irritation each one had but make no promises. I would then give them my problem, namely, that of going from 75 to 100 items per hour. "Can we do it?" "If not all at once, can we hit 80 next week?" Once off this 75 plateau, the job becomes relatively easy.

I would work harder at taking care of their pet gripes than they probably would at getting me on the 80-per-hour level.

The next week we would have another meeting and set the goal for the following week. Of course, during this first week, I would follow this matter closely every day. Indeed, I would put this 75-per-hour bottleneck at the head of the list. After 4 or 5 weeks, I believe I would end up with 100 per hour, and what is even more important a loyal crew which would "go to bat" for me as I would for them.

CONCLUSIONS

There is perhaps no best method for increasing labor productivity in a day-work shop. Assuming a sound industrial-relations program, efficiency is being increased in union shops by using one or more of the following approaches: (1) Maintain direct labor control by (*a*) setting sound and fair standards, and (*b*) keeping hourly production records. (2) Post operator efficiencies in full view of everyone. (3) Vestibule schools for new operators. (4) Threat of dismissal. (5) Redesign the job completely. (6) Get acquainted with your people.

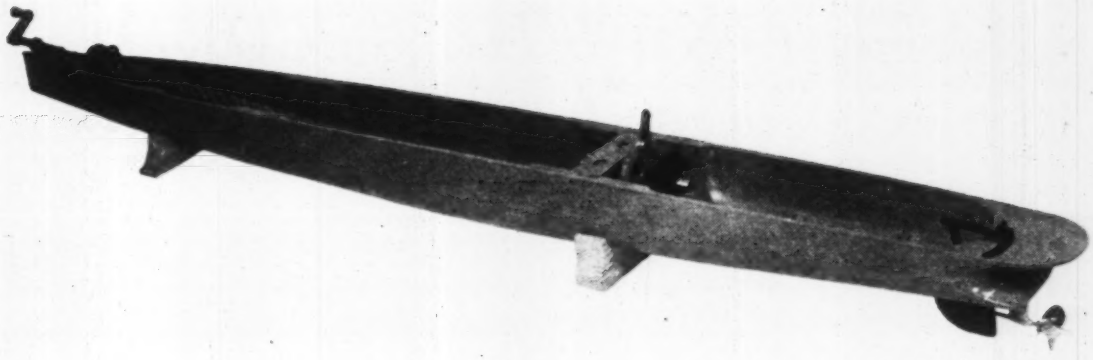


FIG. 1 REPLICA OF EXPERIMENTAL MODEL

SIR CHARLES PARSONS *and the* "TURBINIA"

By H. PHILIP SPRATT

THE SCIENCE MUSEUM, LONDON, ENGLAND. ASSOCIATE A.S.M.E.

IN the workshops at the Science Museum, London, there has been constructed an exact replica of the six-foot experimental model, made and tested by Sir Charles A. Parsons in 1894 to determine what power would be needed to drive his *Turbinia*. Three years later, this famous little vessel, the first ever to be propelled by turbine machinery, made its dramatic appearance at the Naval Review held at Spithead in 1897 to celebrate the Diamond Jubilee of H. M. Queen Victoria.

The spectators were thrilled to see this tiny vessel race down the lines at 34.5 knots, Fig. 2, a speed never before attained on water. In 1927 the afterpart of the *Turbinia* was transported to the Science Museum, where it is still preserved in the National Collections. The three propeller shafts, each with three screws of small diameter in tandem, may be seen, Fig. 3, and part of the starboard side of the hull is replaced by windows to expose the three turbines inside.

The hull of the six-foot experimental model, Fig. 1, was shaped and hollowed out from one piece of yellow pine, stained and varnished on the outside. The propeller was driven by three strands of twisted rubber cord, which were wound up by means of a detachable handle at the bow. Double gearing was used to increase the speed of the propeller; there was a pair of simple spur gears connected to the twisted rubber drive, followed by a pair of finer pitched helical gears to the propeller shaft. These latter were provided with a releasable catch. The screw propeller was three-bladed, about 2.5 in. diam, and the balanced rudder was placed on the port side.

After a certain amount of winding, the rubber strands would coil and knot; first a row of single knots would form, and then as the twisting developed, double and treble knots extending from end to end. Each form of knotting, single, double, or treble, corresponded with a definite twisting moment.

The torque delivered to the screw propeller, which made about 8000 rpm, was determined by substituting for the propeller a simple form of air torsional dynamometer, mounted on almost frictionless bearings. By this means it was possible to eliminate the losses due to friction in the shaft gearing and in the intertwisting rubber.

The resistance of the model was tested by towing it in a pond at the Heaton Works, near Newcastle, Northumberland, with a salmon line and falling weights. This line had two tags 30 ft apart, and the speed of the model was determined from the time which elapsed between the passing of the first and second tags opposite a guidepost. The speed of the propeller was estimated by close observation of the time between double and treble knotting of the rubber, which was found to represent a definite number of revolutions.

From these measurements the slip ratio of the propeller and the required horsepower for the *Turbinia* were calculated. Three years later, the effective horsepower of the *Turbinia* was tested by models in the Froude Tank, near Portsmouth, and was found to be within 2 to 3 per cent of the determinations made by Sir Charles Parsons with this rudimentary apparatus.

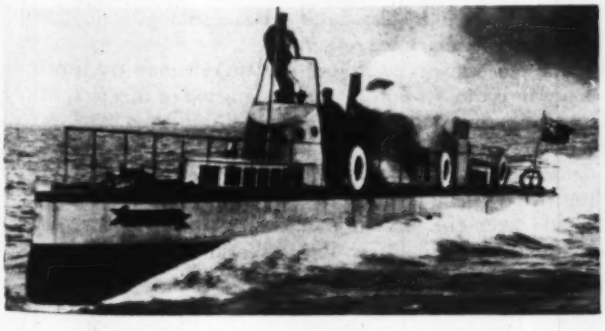


FIG. 2 THE TURBINIA AT SPEED

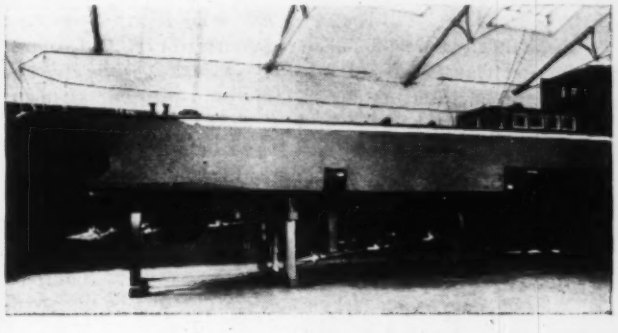


FIG. 3 AFTERPART IN THE SCIENCE MUSEUM

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Air Industrial Preparedness

AS a result of the experiences of World War II, together with the military implications of continuing advances in aeronautics and other sciences, there is a definite need for a peacetime program of preparedness, according to a booklet entitled "Air Industrial Preparedness" prepared by Headquarters Army Air Forces, Air Materiél Command. America must face the possibility of an attack without warning. Furthermore, we must realize that never again will there be the time to convert an unprepared industry to wartime production.

In recognition of such dangers to our national security, and as part of a nation-wide program of industrial preparedness, the War Department has established Air Industrial Preparedness Planning as one of the three primary peacetime missions of the Army Air Forces, sharing an equal place with Scientific Research and Military Training. The Commanding General of the A.A.F. has charged the Air Materiél Command with the major responsibility of developing and implementing Air Industrial Preparedness Planning.

The general concept of air industrial preparedness planning implies: (1) Participation by the Air Services in the over-all program for national industrial preparedness. (2) Co-operation of industry with the Air Services covering the development of specific plans for certain air weapons to insure their rapid production expansion in an emergency. (3) Development and establishment within the Government of plans and measures covering the availability and allocation of the national resources in an emergency. (4) Co-ordination and integration of these industrial plans with current military operations to assure the immediate implementation of the plans.

Air industrial preparedness is applicable to all air materiél including not only conventional aircraft and equipment, but also jet, pilotless, atomic, or any other air weapons resulting from scientific research and engineering development.

In planning any future industrial mobilization for production of air weapons, certain fundamental facts of World War II experience stand out: (1) The average time lag from Government go-ahead on a plane model until the contractor reached volume production was three and one-half years. (2) The average time lag from initiating construction on a new aircraft plant until the first airplane was rolled out the door was one and one-half years. (3) The specialized aircraft industry produced half of the aircraft engines, and accounted for 90 per cent of the airframes assembled (using their own fabrications as well as subassemblies produced by outside sources). (4) It was necessary to supplement the productive capacity of the aircraft industry in order to reach the war volume of air weapons. Industrial facilities of some of our largest corporations and of thousands of small job shops were drawn into production of air materiél. As the war progressed, an ever-increasing proportion of aircraft and components was produced by outside sources. (5) The automobile industry in particular made an invaluable contribution, manufacturing about 10 per cent of our planes, supplying half of the total engines and also producing as subcontractors to the specialized aircraft industry a substantial proportion of total airframes—but around three years were required for this mass-production industry to reach the desired production of airframes, assemblies, and components. (6) Every plane and every engine which saw combat service during World War II was on the drawing board, or in development, prior to Pearl Harbor.

In the event of any future emergency, this country must be prepared to telescope in less than two years the five-year production acceleration record of World War II. To realize such a saving of time, there is being developed a peacetime industrial planning program—the salient features of which can be summarized as "The Four Keys to Air Industrial Preparedness."

The first key is an adequate research and development program that carries through production in at least limited quantities to provide production and service testing.

Industry must do more than make merely experimental versions of the latest and most effective air weapons. Design engineering and production engineering must be integrated—the plane model should be so designed initially that it could be manufactured for volume production without subsequent redesigning.

There should be some production of the model because first, such production orders will enable the manufacturer to production-test the plane model; and second, the existence of a certain minimum number of the model will allow the Air Forces to test the plane's operational and tactical characteristics.

In a total of nearly four years of war this country failed to complete the cycle of designing, engineering, developing, manufacturing, and combat-testing a single airplane. In fact, the average period of design to combat-test was five to seven years, a very long period of time.

The second key is the maintenance of a healthy nucleus of an aircraft industry capable of rapid expansion and supported by a program of continuing military production.

The aircraft manufacturing industry in 1938 ranked 44th compared with other American industries, on the basis of volume of business. By 1944 there were more than two million persons actively engaged in the production of aircraft, and the industry attained the number-one position in rank. Since V-J Day there obviously has been a substantial reduction both in production capacity and resources.

The peacetime condition of our aircraft industry is of great concern to the Air Forces. In recognition of this fact, the Air Co-Ordinating Committee suggested a minimum level of military-aircraft production. It is believed that the recommended figure of at least 3000 military planes, procured every year, together with production for commercial and private sources, should keep the aircraft industry at a healthy level. As a comparison, the industry during World War II produced 3000 aircraft in less than two weeks' time.

This program of military-aircraft procurement would provide a broad base from which production could be expanded rapidly in the event of an emergency, and, it would insure that our Air

Forces during peacetime will receive a sustained flow of aircraft replacements of the latest design and advancements.

The third key is the assurance of an industrial reserve of production facilities and resources.

During the past war the Government invested nearly 4 billion dollars in aircraft-manufacturing plants. The magnitude of this sum perhaps may be better realized by stating that the total net depreciated value of the prewar automobile-manufacturing industry was only about one third of this figure. A number of large, modern, and strategically located airframe and engine plants were constructed, and their disposition posed a great problem.

A "recoverable reserve" has been established covering nine of these Government-built plants, which are being sold or leased to private concerns with the understanding that the Government may recapture them within a specified period, and that no major structural changes be made by the user without permission. Steps are being taken to have comparable reserves of plant capacity in the various industries concerned with potential production of aeronautical products.

A total of 40,000 machine tools have been authorized as an A.A.F. industrial reserve, and a substantial proportion already have been selected from Government-owned stocks and are being prepared for long-term storage.

The fourth key is a program of specific industrial preparedness plans, undertaken jointly between the Air Forces and industry, to maintain our newest air weapons in a state of readiness for volume production.

The objective is to reduce the amount of time required by a company to achieve volume production, after the Air Force has placed a production contract or given its "go-ahead." World War II experience showed that three to four years elapsed between go-ahead and volume output. Industrial preparedness plans can substantially reduce this time lag.

There are numerous and complex problems facing a manufacturer in reaching large-scale production on an airplane. In the first place, the airplane must be broken down into components, assemblies, subassemblies, and so on. Then there are concurrent manufacturing problems, including process engineering, tool design, tool production, and developing sufficient supplies of materials and man power. It is proposed that certain of these difficult and time-consuming steps be undertaken in peacetime on certain of our air weapons. By solving production problems in advance, and preparing for the necessary steps through which an individual manufacturer must go, there will be a production timesaving of many valuable months.

In summary, the Air Forces are concerned with always having a strong air-arm-in-being, together with a supporting industry which provides replacements of superior design and performance for our air groups, carries on its important share in research and development of new types of aircraft necessary to maintain America's leadership in aeronautics, and finally, could expand with sufficient rapidity to meet the mobilization requirements of any future emergencies.

Pressure-Operated Blast Furnaces

MILLIONS of tons more pig iron can be made each year by a new method of blast-furnace operation now coming into use by the iron and steel industry, according to an article in the May, 1947, issue of the *Industrial Bulletin* of Arthur D. Little, Inc. By slight modification, a blast furnace can be throttled to operate under a pressure substantially above normal, with a resulting 20 per cent increase in its output and a 12 per cent reduction in coke consumption for each ton of iron produced. These gains have been shown at two furnaces operated by Republic Steel Corporation since August, 1946, under a pressure at the top of the furnace of 10 psi This company is converting several other furnaces to pressure operation. Republic is working under a license agreement with Arthur D. Little, Inc., which is prepared to license the industry generally. Several other steel companies, here and abroad, are planning conversions, and the process is under engineering investigation by still others. The full-scale tests were first described technically before the American Iron and Steel Institute on May 21, 1947, by J. H. Slater of Republic Steel Corporation.

In blast-furnace operation, iron ore, coke, and limestone are fed in at the top of the furnace and air is blown in at the bottom to burn the coke, to provide the high temperature necessary for smelting the iron ore to pig iron, which is drawn off molten at the bottom. In normal operation, the air blast blows a good share of the iron ore out at the top as dust; if the rate of blowing is increased above the standard, this loss becomes unbearably great. With the furnace throttled for pressure operation, it has been possible to increase the rate at which "wind" is blown into a big blast furnace from 75,000 to 120,000 cfm, the most ever blown. Despite this rate of operation, the amount of flue dust blown out of the furnace is substantially reduced, since the velocity of the gases through the furnace is less at the higher pressures. With this higher input of wind, more coke can be burned and more iron produced each day. At the same time, coke consumption per ton of iron is reduced substantially. With a large furnace consuming 1000 tons of coke a day, and with coke prices rising, this saving is important, particularly now, because supplies of the best coking coal are becoming exhausted, and lower-grade coke introduces impurities which must be removed. Reduced coke consumption alleviates this problem.

Several factors are combining now to give the blast furnace a new importance. Normally, most of its pig iron is combined with about an equal amount of scrap iron or steel to make steel in the open-hearth furnace. Steel production now, however, is so high that the inexpansible scrap supply cannot bear its share of the raw-material burden, and the price of the scarce scrap has soared. The blast furnace, the output of which can be expanded, thus becomes a key factor in determining steel output. Furthermore, cheap oxygen is becoming available, and may soon be used in quantity in the open hearth to increase steel production, with a resulting need for more pig iron. Behind all such technical factors lies the present steel and iron shortage and the possibility that present steel capacity may be permanently too small for the nation's postwar level of industrial production, a matter now being investigated by the Federal Trade Commission. Pressure operation and use of oxygen appear to offer the steel industry the opportunity to increase capacity for pig iron and steel, respectively, without expensive and time-consuming construction of new blast furnaces and open hearths.

About one tenth of the pig iron produced is used directly for cast-iron products, including such critical housing items as bathtubs, radiators, and soil pipe. With the pig-iron supply limited, producers tend to use it in their own open hearths for steel, rather than to sell it to foundries. Any increase in pig-iron production will make more of these products available for housing.

Many blast furnaces in the United States have excess blower capacity and can convert to pressure operation inexpensively within a few days after obtaining the required components. Some will require new blowers, with the conversion costing about $500,000, much less than the $6,000,000 for a new blast furnace. Republic Steel is converting several furnaces, and has ordered the largest blast-furnace blower ever built, capable of delivering 125,000 cu ft of air per min compressed to 40 psi.

This blower, built by Ingersoll-Rand Company, will push 6900 tons of air into the furnace each day, a weight greater than that of all the iron ore, coke, and limestone used.

Fire-Test Building

DEVELOPMENT of better fire protection for industry will be facilitated by the recent completion of a large fire-test building at the Norwood, Mass., research station of the Factory Mutual Laboratories, permitting investigation of industrial fire problems on a scale not hitherto possible.

The new structure is representative of a typical plant building, but specially constructed to permit interior test fires with a minimum of damage to the building itself. The effects of fires similar to those likely to involve any industrial process, storage, or construction can now be studied directly. Duration of fires, rapidity of fire spread, and the effect of liberated heat beyond the fire area can be accurately measured with the help of the latest type of high-speed electronic recording equipment. Fire-fighting problems can be investigated under the same heat and smoke conditions that would prevail in an actual plant. These facilities will be used to obtain reliable answers to many long-standing fire problems.

Combustion-Compressor Locomotive

A METHOD of using combustion gases as a medium of energy transmission in locomotive power plants was described in a paper by Prof. Gerard E. Unger, member A.S.M.E., Escuela Nacional de Ingenieros, Lima, Peru, at a meeting of the Oil and Gas Power Division of the A.S.M.E., held in Cleveland, Ohio, May 21–24, 1947.

Basically, the system consists of generating power by combustion under pressure and using the combustion gases, either not expanded at all or partially expanded, as a medium of energy transmission to drive a reciprocating expansion engine directly connected to the locomotive wheels.

Pressure gases can be produced by a modified Diesel engine, a so-called "combustion compressor," or by means of turbounits and the constant-pressure gas-turbine cycle (Brown Boveri or Allis-Chalmers type gas turbine).

In a combustion compressor, see Fig. 1, the compressed gases are taken from the cylinder of an internal-combustion engine and used directly as a medium of energy transmission. The difference between this and a standard Diesel cylinder would be that a combustion-compression cylinder would have, besides the intake and exhaust valves, an additional discharge valve which would be connected to a receiver for the combustion gases.

OPERATION

Referring to Fig. 1, during the first descending stroke of the piston the intake valve *a* would be open, admitting air. During the first ascending stroke all valves would be closed, compressing the air. At the end of this stroke fuel is injected through the fuel-injection valve *d* starting combustion. During the second descending stroke combustion is completed and the expansion of the gases begins. This is interrupted when the discharge valve *b* opens, connecting the cylinder to the receiver *e*. During the second half of this stroke the gases flow from the receiver into the cylinder. During the second ascending stroke the piston forces the gases into the receiver, the discharge valve having remained open. Shortly before

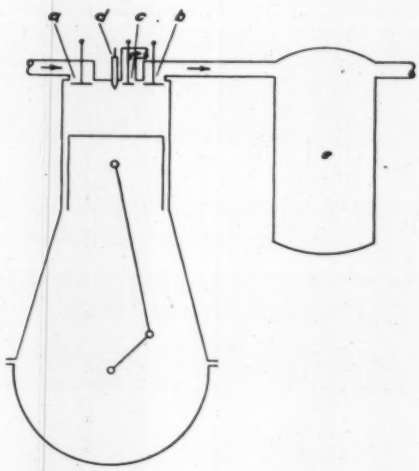


FIG. 1 DIAGRAM OF COMBUSTION COMPRESSOR
(*a*, Intake valve; *b*, discharge valve; *c*, exhaust valve; *d*, fuel-injection valve; *e*, receiver.)

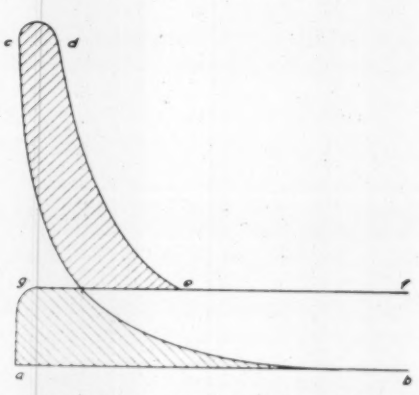


FIG. 2 P-V DIAGRAM FOR CYCLE OF COMBUSTION COMPRESSOR

the piston reaches top dead center, the discharge valve closes and the exhaust valve *c* opens for a short period of time, dropping the pressure in the cylinder to atmospheric and completing the cycle.

Fig. 2 shows the P-V diagram for this cycle: *a-b*, intake; *b-c*, compression; *c-d*, combustion; *d-e*, expansion; *e-f*, flow of gases from receiver to cylinder; *f-g*, flow of gases from cylinder to receiver; *g-a*, exhaust.

COMBUSTION-COMPRESSOR LOCOMOTIVE

The operation of a combustion-compressor locomotive, see Fig. 3, is as follows: The combustion compressor *a* furnishes compressed gases to the receiver *e*. From the receiver the gases flow to an expansion engine *b*, and drive it. The expansion engine, in turn, drives the locomotive wheels *c*. The gases, partly expanded in the expansion engine, flow to a turbocharger *d* and thence are exhausted to the atmosphere. The incoming air enters the compressor of the turbocharger, leaves it at a slightly increased pressure, and flows to the combustion compressor.

Assuming an efficiency of 37 per cent for the Diesel and 81 per cent for the expansion engine, the over-all efficiency of the system would be about 30 per cent, without taking into account friction losses at the locomotive wheels. This efficiency is slightly lower than that of a standard Diesel engine using electric transmission.

The weight of the combustion-compressor expansion-engine combination would be less than that of a Diesel-electric engine for the following reasons: The expansion engine weighs less than the electric motors, and the combustion compressor would weigh less than a Diesel of the same power because it does not need so large a flywheel. The weight of the auxiliary equipment (starter, brakes, control mechanisms) would weigh the same and the weight of the generator would be completely saved.

In comparison with a 1000-hp steam locomotive the expansion engine would weigh the same. The boiler weighs about 33 tons, and two modern supercharged Diesels of 500 hp each weigh about 20 tons, including the auxiliary engines. The weight of the boiler feedwater would be saved and the weight of the fuel reduced. This saving of weight would be somewhat less than indicated because of the necessity of using a receiver, but would be in excess of 10 tons.

Since the expansion engine is similar to a steam engine the method of regulation would be similar.

The initial cost of the expansion engine itself would be lower than that of the Diesel-electric. The fuel consumption would be substantially the same. Therefore its cost would be less in comparison with the Diesel-electric if both engines used the same fuel. The advantage or disadvantage in comparison with the steam engine depends upon the relative prices of coal and Diesel fuel.

GAS-TURBINE LOCOMOTIVE

The gas-turbine locomotive would resemble a combustion-compressor locomotive in its use of pressurized combustion gases in a reciprocating expansion engine with a direct drive of the locomotive wheels, the difference lying in the method of production of the pressurized combustion gases. In the combustion compressor, the gases have been taken from the cylinder while in the process of expansion; in the gas turbine they are taken from the combustion chamber which works under constant pressure. The combustion chamber receives the compressed air to support combustion from a compressor driven by a gas turbine.

Fig. 4 shows a schematic diagram of an expansion engine and a gas turbine working in parallel.

The combustion chamber *c* furnishes compressed gases to the expansion engine *d* and to the gas turbine *a*. The gases ex-

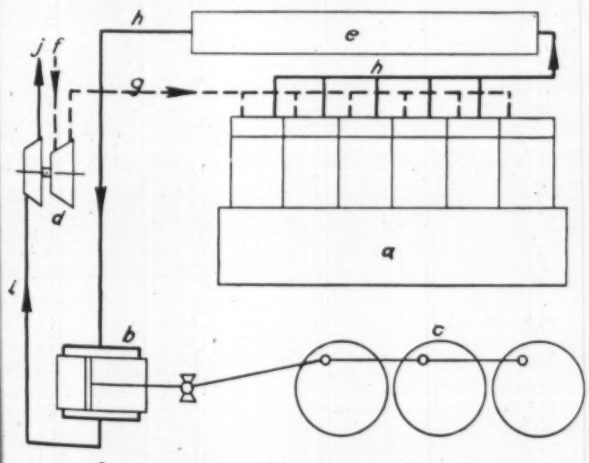


FIG. 3 LOCOMOTIVE WITH COMBUSTION COMPRESSOR

(*a*, Combustion compressor; *b*, expansion engine; *c*, locomotive wheels; *d*, turbocharger; *e*, receiver; *f*, ambient air; *g*, precompressed air; *h*, pressurized combustion gases; *i*, partially expanded gases; *i*, exhaust.)

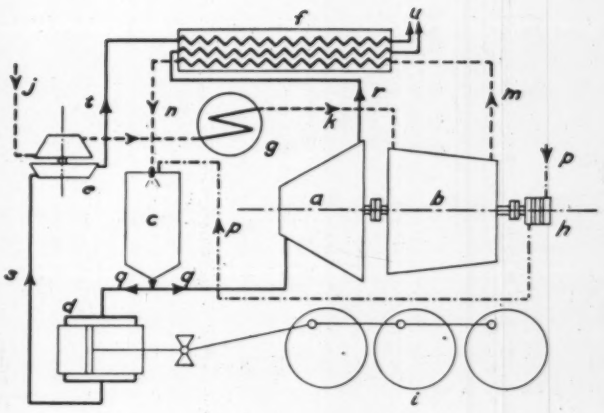


FIG. 4 EXPANSION ENGINE AND GAS TURBINE WORKING IN PARALLEL

(*a*, Gas turbine; *b*, turbocompressor; *c*, combustion chamber; *d*, expansion engine; *e*, turbocharger; *f*, regenerator; *g*, intercooler; *h*, fuel pump; *i*, locomotive wheels; *j*, ambient air; *k*, precompressed air; *m*, compressed air; *n*, preheated air; *p*, fuel; *q*, pressurized combustion gases; *r*, exhaust from gas turbine; *s*, partially expanded gases; *t*, exhaust from turbocharger; *u*, exhaust from regenerator.)

pand in the expansion engine, drive the locomotive wheels *i*, leave the expansion engine, and enter the turbocharger *e*. From the turbocharger they pass through the regenerator *f* where they transmit their residual heat to the incoming compressed air. The pressurized gases from the combustion chamber also enter the gas turbine which drives the turbocompressor *b*. They mix with the gases from the expansion engine and turbocharger before passing through the regenerator. Air at atmospheric pressure is drawn in by the turbocharger, cooled in the intercooler *g*, compressed in the turbocompressor, and preheated in the regenerator. The air then enters the combustion chamber where it is used to support combustion of the fuel injected into the chamber by the fuel pump *h*.

Since gas under the same conditions of temperature and pressure is used for both the expansion engine and for the turbine, it has been necessary to limit the inlet temperature to 627 C.

Using this temperature, an efficiency of 22 per cent can be expected. This, however, does not take into account the friction losses of the locomotive wheels.

In comparison with the Brown Boveri gas-turbine locomotive with electric transmission, the expansion-engine gas-turbine locomotive would be lighter by the weight of the electric generator and train of gears, and by the difference in weight between the electric motors and the expansion engine. This assumes that the heat exchanger would be of the same size in both and that the weight of the expansion engine, with its connecting rods and turbocharger, is less than the weight of the driving motors.

The proposed locomotive would have substantially the same fuel consumption as the Brown Boveri locomotive but could be produced for a lower initial price.

In his summary Professor Unger stated that it would be possible to build locomotives similar to steam locomotives with expansion engines equipped for fluid transmission of energy by using compressed gases instead of steam as the working fluid. The compressed gases can be produced in combustion compressors or in constant-pressure combustion chambers with gas turbines as auxiliary engines. The over-all efficiency will depend upon the cycles and temperatures used, and will probably vary between 22 per cent and 30 per cent.

In countries where the price of fuel oil is low, such locomotives could compete with all existing types. In countries where the cost of fuel oil is high relative to that of coal, such a locomotive might compete with the steam engine, depending upon the relative prices of coal and oil. However, if the investigations being carried out to find a method of burning coal in gas turbines are successful, the gas-turbine locomotive could compete with all types of locomotives in present-day use.

Overfire-Air-Jet Clinics

WITH an increasingly large number of coal-company fuel engineers faced with design problems as the demand builds up for modern overfire air jets in smoke-abatement work, the coal industry's research agency, Bituminous Coal Research, Inc., recently began a series of "Jet Clinics" to provide up-to-the-minute information on installations for all types of commercial and industrial plants.

The first meeting, held in Pittsburgh, Pa., was conducted by William S. Major, member A.S.M.E., BCR development engineer. He was assisted by Howard Herder, fuel engineer, Sahara Coal Company, and R. L. Sutherland, member A.S.M.E., combustion engineer, Truax-Traer Coal Company, Pittsburgh, Pa. More than 30 engineers attended the clinic, heard a lecture by Mr. Major on "Modern Overfire Air Jets and Smoke Abatement," and then solved jet problems, using special work sheets provided for the purpose.

Three typical problems were available. The engineers made use of Technical Report No. VII, "Application of Overfire Jets to Prevent Smoke in Stationary Plants," published by BCR, as well as additional information furnished by Mr. Major. Discussion followed both the lecture and the work period.

Those in attendance suggested that another clinic be held in Chicago within six months. It is expected that similar meetings will be requested by engineers in other coal-marketing centers of the United States.

Engineering Developments

VARIOUS engineering developments, equipments, and trends, were described by E. E. Johnson, manager of engineering, Apparatus Division, General Electric Company, at the 19th conference of the Oil and Gas Power Division of The American Society of Mechanical Engineers, held May 21–24, 1947, in Cleveland, Ohio. Mr. Johnson discussed steam and gas-turbine power plants, transportation, new instruments, electronics, nuclear power, and many others.

POWER PLANTS

In the steam-turbine generator field, there is being designed a 125,000-kw cross-compound unit for operation at 2000 psi, 1050 F initial, and 1000 F reheat. It is expected that this unit will give the lowest heat rate so far realized with a steam cycle.

A nonaircraft gas-turbine power plant, designed primarily for locomotive use, is now under construction. The power plant is of the simplest type without regeneration or intercooling. The combustion chambers are of the straight-through all-metal type.

The unit is rated at 4800-shaft hp and runs at 6700 rpm. The rated inlet temperature to the turbine is 1400 F, and the thermal efficiency is about 18 per cent based on the lower heating value of the Bunker C fuel. It is approximately 19 ft long and weighs between $3\frac{1}{2}$ and 4 lb per hp.

A 5000-kw gas-turbine plant suitable for central-station or industrial applications is being designed. This plant incorporates an intercooler and regenerator to improve the thermal efficiency which is expected to be around 29 or 30 per cent based on the shaft output and the lower heating value of Bunker C fuel.

TRANSPORTATION

In the field of transportation, the present indications are that electric surface transportation vehicles are regaining popularity in spite of the large number of automotive transit buses which are now being supplied to industry.

The trolley coach appears to be a keen competitor for the automotive bus on all lines where traffic requires vehicle operation on less than 12 to 15-min headways. Economic analyses of many operating systems show conclusively that the trolley coach has the lowest operating cost and the highest income of any transit vehicle operating in service of medium density of traffic.

NEW INSTRUMENTS

A flaw detector has been developed for the continuous inspection of sheet material such as paper, mica, or plastics. It locates small holes, conducting paths, or metallic inclusions in the sheet material. The flaw detector will count the presence of minute faults on sheets moving as fast as 300 fpm.

An x-ray thickness gage is nearing completion for measuring continuously the thickness of hot-rolled strip steel moving at speeds up to 30 mph. By continuously measuring the thickness of red-hot steel (without making contact with the steel), this equipment allows the steelmaker to control the thickness more accurately and therefore may promote substantial increase in the speed of rolling.

An x-ray photometer provides the chemist with a precision-measuring equipment for the purpose of continuously indicating the content of one solution in another or the proportion of one gas mixed with another gas. It is expected that the x-ray photometer will be useful for routine analysis of the ash content of coal without burning the coal, the chlorine content of chlorinated polythene, and for many other routine tests.

A pneumatic-type fatigue tester makes tremendously accelerated fatigue tests on not only test specimens of materials but also on completed parts by vibrating them at resonant frequency at which lowest power is required, yet highest testing speed is realized. It was developed for testing materials and shapes used as buckets for high-speed gas turbines.

A new torque meter has been developed for the purpose of measuring torque transmitted by a rotating shaft at speeds of 35,000 rpm.

A thickness gage for measuring the wall thickness of pipes and tanks from the outside has been developed.

A dew-point measuring device which is used to determine the moisture content of gases is being manufactured. It will detect moisture in as small amounts as 3/10,000 of 1 per cent by volume.

Another device known as the leak-detector can detect a leak so small that only one cubic centimeter of helium at atmospheric pressure is passed through the opening in 16 years. It is used to detect, locate, and evaluate small leaks in vacuum systems.

New light and lighting instruments include a small light meter with built-in filter and lens system which accurately corrects for the color and incidence angle of the light. Such a meter will be commercially available in the future.

Two instruments have been developed for germicidal energy applications: an ultraviolet meter to measure low-intensity radiation, and a meter to read the effective output of germicidal lamps.

CHEMICAL FIELD

Dri-film, a chemical development, is useful in solving many problems involving difficulty because of water. For example, there seems to be great potential use for this material in the treatment of textiles for rain and stain resistance. It is claimed that Dri-film provides not only an excellent water-repellant treatment, but improves the physical feel of goods, and the durability and permanence when dry-cleaned. It is also finding applications on aircraft for keeping windshields clear and for de-icing.

Silicones are also coming into important uses, some of which are as follows: (1) Silicone oil which maintains a fairly uniform viscosity over extremely wide temperature limits will probably be useful in aircraft hydraulic systems as well as for lubrication of bearings which are subjected to large ranges of temperature in an airplane; (2) silicone rubber, which has high resistance to chemicals and to high temperatures, found great use on searchlights used by the Army and Navy. Because it also has low-compression set silicone rubber is coming into use as gaskets for cylinder blocks, high-temperature ovens, and capacitors.

ELECTRONICS

A solution of airplane navigation problems, because of weather, through the use of radar-equipped airplanes is being investigated and an ultimate solution is expected.

Radar equipment installed on airplanes makes it possible to see and circumvent thunderstorms which the plane is approaching, and even learn from the patterns appearing on the screen, the moisture content of the storm. Such equipment already is installed on an American Airlines airplane for experimental purposes.

Electronics has found its way into the frozen-food business and a heater for the quick thawing and heating of precooked frozen foods will soon be available. This unit will heat a complete 12-ounce meal in about one minute.

HOME APPLIANCES

There will soon be available an automatic clothes washer whose time cycle of washing, rinsing, and drying can be adjusted to suit the type of clothing being washed. The washing is done by a reciprocating agitator and the drying by centrifugal force in a basket which rotates at 1100 rpm instead of the former speed of 450 rpm, the result being that the clothes will be ready to iron when they are removed from the machine.

A dishwasher is also being manufactured which, except for loading of the dishes and of the detergent, does the entire job automatically, including the drying of the dishes.

X RAY

Considerable promise in both medical and industrial applications is offered by the betatron principle of x ray. Since the principle permits generation of x rays far above the present 2,000,000-volt level, it opens up an entirely new field. It appears that 10,000,000-volt units will be the best for industrial radiography, and 50,000,000 to 75,000,000-volt machines for medical therapy.

NUCLEAR POWER

As to the application of atomic energy for power-plant use, Mr. Johnson stated that nuclear power is suitable for large land-power plants where weight is no consideration or for marine power plants where the combined weight of the plant and fuel for a given period of operation is less than for other fuels. These seem at the present to be the two most likely first developments.

Material-Handling Equipment

A BRIEF review of recent and future developments in the electrical fields which apply to material-handling equipment, was presented by C. B. Risler, material-handling engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa., at the Pittsburgh Mechanical Engineering Conference, held in Pittsburgh, April 22, 1947. The American Society of Mechanical Engineers, Engineers' Society of Western Pennsylvania, Society for the Advancement of Management, and the Material Handling Society participated in the program.

Some of the developments discussed by Mr. Risler are already available, others are in the test stage, and still others have advanced no further than the drawing board. It is these developments, however, which will permit the machinery designers to put into effect those ideas for the design of new and better material-handling apparatus.

There has been a trend toward a new line of squirrel-cage alternating-current motors. The new designs secure the same horsepower and torque performance out of a motor of smaller diameter and height and of lighter weight. A description of a motor of this type appears in MECHANICAL ENGINEERING, November, 1946, page 984.

Direct-current mill motors as standardized by the Association of Iron and Steel Engineers are being redesigned. Again, the trend is for small size and less weight, and in the mill motor the aim is to get the present rating in the next smaller size than at present. Here there has not been any major change in the frame sizes of the motors but rather just moving the ratings down one frame size.

The use of new and improved types of insulation materials characterized by a combination of glass and silicone varnishes and resins provides improved thermal characteristics and resistance to moisture over those materials now in use. Their use will permit motors at higher temperatures than now in general use—leading to smaller lighter machines in many cases.

A general redesign of steel-mill heavy-duty direct-current contactors is in progress. Improvement in the performance of the contactors under adverse operating conditions such as dirt and magnetic dust is anticipated. The trend is toward improved reliability and appearance with savings in space and weight secondary. In smaller direct-current contactors the trend is toward having two models of the same general type of contactor, a space-saving type for cramped applications, such as machine tools, and a type with wide spacing for the heavy-duty industrial jobs.

With trolleys on large gantry bridges reaching travel speeds of 900 fpm, a need developed for a track-type limit switch capable of withstanding this duty. Existing track switches proved inadequate and a new one has been developed within the last year meeting the qualifications.

Much development has taken place in the field of alternating-current crane-hoist controllers with particular emphasis on methods of electrical retardation for lowering over-hauling loads. Progress toward improvement and simplification of the drives as now conceived is anticipated. In designing apparatus and making new applications the speed-torque characteristics produced by these recently developed crane-hoist drives bear serious consideration for other uses than just crane hoists. Among such possibilities are trolley travel drives, movable highway and railroad bridges, aerial tramways, and dragline systems, to name a few.

The variable-voltage drive based on the fundamental principles of the Ward Leonard system is still active and is constantly providing new performance characteristics from the standpoint of speed ranges, accuracies, and speed matching. The per-

formance possibilities of these variable-voltage drives have been greatly enhanced by the use of supplemental rotating amplifiers and regulator devices such as the Rototrol.

Development of electronic apparatus received a tremendous impetus during the war. Although many of these developments are along lines which at present seem remote from material-handling problems, it is interesting to note the progress made in building equipment to withstand severe service and vibration conditions. At present the industrial electronic development program has reached the stage of simplification and of designing specifically for the industrial market. For instance, in a recent redesign of a regulator system there was a reduction in the number of tubes required by the ratio of 3 to 1. It is anticipated that this trend will continue, and that using apparatus built specifically for industrial purposes, electronic equipment will in the near future become a potent material-handling tool.

Much progress was made during the war in the development of finishes and protective coatings for apparatus.

A magnetic strain gage of reliable performance and with simple associated equipment will soon become available to the material-handling industry, which can be applied by the machinery builders to various needs in the way of load limiting, insuring stability, and general test work.

The enclosing of bare collector and trolley wires which serve overhead cranes and monorail equipment eliminated the hazard of sparking or of employees coming in contact with live wires.

Nuclear Energy

THE Navy Bureau of Ships has established an internal organization for the handling of nuclear matters, including studies of the possible application of nuclear power to ship propulsion.

Three new sections of the Bureau have been set up under a co-ordinator and deputy co-ordinator for nuclear matters. They are a Radiological Safety Section, Atomic Warfare Defense Section, and Nuclear Power Section.

The Radiological Safety Section is responsible for the functions assigned to technical sections with respect to matters pertaining to individual radiological protection of personnel from atomic explosions and from radiological ship contamination. Specifically, it is called upon to initiate a program of research, development, and testing to determine means of individual protection of personnel aboard ships and in other activities under the cognizance of the Bureau of Ships, and to develop specifications and initiate procurement of required protective equipment; to initiate a similar program to determine materials, methods, and equipment for decontamination of ships; and to develop specifications and initiate procurement of required materials and equipment.

The Atomic Warfare Defense Section is responsible for the scientific investigation and development of measures to protect ships against atomic weapons and to increase their resistance to damage by such weapons. The specific duties of this section involve the introduction of necessary characteristics and features in ship design for the collective protection of personnel from blast, pressure, heat, and radiation from atomic weapons; and for continuing studies of the results of Operation Crossroads in order that these may be applied, as warranted, in ship design.

The Nuclear Power Section is responsible for all matters connected with possible future application of nuclear power to ship propulsion, and the shielding of personnel from radioactivity resulting from the operation of nuclear power plants in conjunction with the Radiological Safety Section.

Capt. Logan McKee, U.S.N., director of ship design, and Capt. Albert G. Mumma, U.S.N., deputy director of design were named Co-ordinator and Deputy Co-ordinator for Nuclear Matters, respectively, and will function in the dual capacities. They have the responsibility of co-ordinating all nuclear matters involving the Bureau of Ships, whether under the cognizance of the Bureau, within the Bureau, or between the Bureau and other bureaus and offices of the Navy Department.

In addition to the three new Bureau sections, the Electronics Design Branch, Special Application Section, and Electronics Equipment Section of the Bureau are given additional duties in connection with the new program.

The Electronics Design Branch is responsible, in addition to its presently assigned duties, for the scientific investigation, development of measures, and dissemination of information within the Electronics Division, with the intent of increasing the resistance of electrical-equipment weapons. This section will continue analysis of data and application of Operation Crossroads lessons, as warranted to electronic-equipment design.

The Special Applications Section assumes the additional responsibility for the design and development of instruments for detection and measurement of radioactivity and for detection of concentrated fissionable material. It is contemplated that this design work will be co-ordinated with War Department agencies through the Joint Research and Development Board. Close co-ordination with the Radiological Safety Section also is considered a requisite.

The Electronics Equipment Section assumes the additional responsibility for procurement of radiological instruments as authorized and directed by the Radiological Safety Section.

Aircraft Gas Turbines

SPECIFICATIONS of the G-E TG-100 and TG-180 aircraft gas turbines have been released with approval of the Army Air Forces, by the Aviation Divisions of the General Electric Company.

The TG-100 aircraft gas turbine, known in the A.A.F. as the T-31, drives a propeller and boosts with jet propulsion simultaneously. It was first flown in 1945 in the Consolidated Vultee XP-81 A.A.F. escort fighter, and since then has flown in the Ryan XF2R-1 jet fighter, the Navy's first combat aircraft with a gas turbine driving a propeller.

The TG-180, or A.A.F. J-35, a pure jet engine, powers the Republic P-84 "Thunder Jet," which holds the unofficial American airspeed record of 619 mph, and the Douglas XB-43, America's first jet-propelled bomber. It is also used in the Douglas D-558 "Skystreak," recently announced as the Navy's transsonic aircraft designed to challenge and surpass present-day limitations of speed in the range between 600 and 750 mph. The Northrup YB-49, the A.A.F.'s jet version of the "Flying Wing," is powered by eight of these engines. The first four-engine jet bomber to take to the air was the A.A.F.'s XB-45 medium bomber, built by North American and powered by four TG-180 engines. In April of this year the Consolidated Vultee XB-46 bomber, also powered with four TG-180's, made its initial flight.

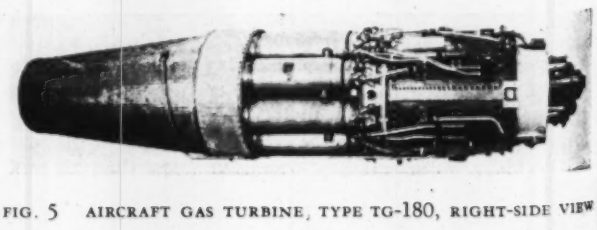


FIG. 5 AIRCRAFT GAS TURBINE, TYPE TG-180, RIGHT-SIDE VIEW

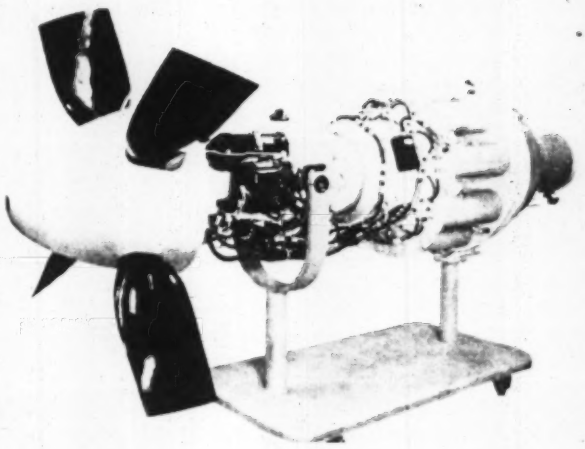


FIG. 6 AIRCRAFT GAS TURBINE TYPE TG-100, INCLUDING PROPELLER, LEFT-SIDE VIEW

The TG-100 (A.A.F. T-31) propjet gas turbine has a 14-stage axial-flow compressor; nine reverse-flow type, interconnected, tubular, combustion chambers; a one-stage axial-flow turbine; and a geared propeller drive.

Its dimensions are: Diameter (maximum) 37 in., length 113 in., and weight (without propeller hub or generator) 1955 lb.

The TG-180 (A.A.F. J-35) turbojet has an 11-stage axial-flow compressor; eight direct-flow, interconnected, tubular combustion chambers; and a one-stage axial-flow turbine.

It is 37.5 in. in diameter, 166 in. in length, and weighs 2400 lb.

Technical Institutes

A THIRD annual survey of technical institutes has been prepared by Leo F. Smith, chairman, Educational Research Office, Rochester Institute of Technology, the results of which are presented in the May, 1947, issue of *Technical Education News*. The results of Mr. Smith's second annual survey of technical institutes appears in the August, 1946, issue of MECHANICAL ENGINEERING, pages 736 and 737.

The present survey was made during January, 1947, and all of the institutions contacted were asked to give enrollment figures as of Jan. 2, 1947. The definition employed this year was the same as a year ago and is one which was prepared by a committee of the Engineers' Council for Professional Development, under the chairmanship of Dean H. P. Hammond, member A.S.M.E. Inasmuch as this definition applies only to curricula in the engineering fields, the respondents were also asked to include enrollment in curricula such as agriculture, home economics, and applied art if these were integral parts of the institute and if high-school graduation were required for admission. It is believed that the inclusion of such curricula gives a more accurate picture of technical-institute enrollment.

To simplify the compilation of data, institutes were classified according to type or control as follows: State maritime academies and federal schools; state and municipal technical institutes; privately endowed technical institutes; extension divisions of colleges and universities; proprietary technical institutes; and Y.M.C.A. schools. During the present survey replies were received from 77 schools as compared with replies from 69 a year ago.

The data regarding enrollment in the several types of institutes reveal that for the 77 schools reporting there were 29,130 regular day students enrolled as of Jan. 2, 1947. This compares with 13,007 students enrolled in 69 institutes in 1945–1946. In addition, there were 20,305 evening and special students, which compares with 8072 reported a year ago. The grand total of 49,435 reported this year compares with 21,079 enrolled in 1945–1946.

STATE MARITIME ACADEMIES AND FEDERAL SCHOOLS

The data regarding the state maritime academies and federal schools show that 1289 students were enrolled, which compares with an enrollment of 2257 in 1945–1946. The U. S. Maritime Service Officers' Schools were discontinued as officers' schools during the first half of 1946. In their place a peacetime-training program for merchant seamen was to be inaugurated in January, 1947. A variety of short intensive courses are to be offered for both unlicensed seamen and officers.

The A.A.F. Institute of Technology was established in December, 1945, with headquarters at Wright Field, Dayton, Ohio, and is conducted by the Air Materiél Command. An article on this institution appears in MECHANICAL ENGINEERING, March, 1947, pages 230 and 231.

STATE AND MUNICIPAL INSTITUTES

The data for the state and municipal technical institutes show that the regular day enrollment in the 20 institutes surveyed totals 5528, which compares with a total of 1837 for 16 institutes reporting in 1945–1946.

On April 6, 1946, Governor Thomas E. Dewey of New York signed a bill providing for the establishment, on an experimental basis, of five technical institutes to be operated at state expense for five years at Binghamton, Buffalo, New York City, Utica, and White Plains. These schools are in various stages of organization but all are expected to be enrolling students by September, 1947, or earlier.

The Milwaukee Vocational School is now in a process of reorganization and the nine divisions are being co-ordinated so that out of the total will come four major divisions. One will be the new Institute of Technology and another will be the new Institute of Business Education.

PRIVATELY ENDOWED INSTITUTES

The privately endowed technical institutes show day enrollment of 4667 students for the 14 institutes reporting as compared with a total of 1783 for 14 institutes reporting in 1945–1946. These are not the same 14 schools, however.

The Rochester Institute of Technology has just completed a $1,000,000 building, which houses the mechanical, publishing and printing, and photographic technology departments. The moving of these departments to the new building has made possible an expansion throughout the entire school.

At the LeTourneau Technical Institute of Texas the student is employed by the R. G. LeTourneau Company in the same field as his course objective. He attends his basic academic classes one half day and works at his objective in the plant under an institute instructor the other half day.

EXTENSION DIVISIONS OF COLLEGES AND UNIVERSITIES

This year for the first time the category Extension Divisions of Colleges and Universities has been utilized.

In the fall of 1946 the University of Minnesota founded an Institute of Technology designed to offer 11 two-year curricula for technical aides. The entrance requirements to these courses were the same as for the regular course in engineering. A recent letter from the dean of this institute states that so few veterans were interested that all of the courses have been or are about to be abandoned.

Oklahoma Agricultural and Mechanical College has opened the Okmulgee Branch on the former site of the government's $1,000,000 Glennan Hospital with a campus of 164 acres. This branch is for veterans only and two divisions of training are offered; one is for lower-division college freshmen and sophomores and the other is the School of Technical Training The four fields of training in the technical school are the following: Agriculture, intensive business, foods, and industrial. The courses range from 3 months to 2 years in length. The enrollment in these four fields was 424.

The Pennsylvania State College Extension Division operates 13 evening technical institutes at Allentown, Altoona, Chester, Coatesville, Erie, Harrisburg, Lancaster, Reading, Scranton, Sharon, Westmoreland, Wilkes-Barre, and York. The courses of instruction vary from 1 to 5 years in length and classes usually are held two evenings a week for approximately 2½ hours. The total enrollment in the 13 institutes was given as 2396.

Purdue University Division of Technical Institutes reports a full-time day enrollment of 428 as contrasted with 42 one year ago. The total 1946–1947 day and evening enrollment of 1020 compares with 474 in 1945–1946.

Utah State Agricultural College operates a technical-institute program in the Industrial Division of the School of Engineering, Industries, and Trades. The courses of instruction vary from two to four years in length and a total of 419 full-time day students and 1802 special students was reported.

PROPRIETARY TECHNICAL INSTITUTES

The answers received from the proprietary technical institutes indicate a regular day enrollment of 15,769 for the 25 schools reporting as compared with an enrollment of 6980 for the 27 schools reporting in 1945–1946.

Chicago Technical College reports an interesting pay-incentive plan for teachers in which they are rated on eight points by the administrative staff. Educators have long debated the desirability of a merit-rating system for teachers, and if this institution can solve some of the difficulties, the plan may have widespread implications.

It is interesting to note that two aviation schools in this category, Parks Air College and the Hancock College of Aeronautics, have become the colleges of aeronautics of two privately endowed universities, St. Louis University, and the University of Southern California, respectively.

Y.M.C.A. SCHOOLS

The data obtained from the Y.M.C.A. schools reveals a regular day-school enrollment of 606 from the three schools reporting. This compares with a total day-school enrollment of 150 reported in 1945–1946.

CONCLUSIONS

Some of the generalizations drawn from this third survey are:

1 That the technical institutes have been influenced by the tremendous demand for higher education is evidenced by the grand total of 49,435 enrolled this year as compared with 21,079 enrolled in 1945–1946.

2 If the experience at the University of Minnesota is to be taken as an example, it would appear that it is difficult, if not impractical, to attempt to carry on technical-institute curricula in the same institutions and buildings in which engineering curricula are offered.

3 Technical-institute curricula offered by colleges and universities in off-campus locations, however, appear to be one solution to the difficulty outlined in the foregoing paragraph. Those institutions operated under the direction of Oklahoma Agricultural and Mechanical College, Pennsylvania State College, and Purdue University are examples.

It has been interesting to note the increasing number of references which have appeared during the past year concerning the need for technical-institute type of training. For example, President Truman, in outlining areas of study for the Commission on Higher Education which he appointed, said, "Among the more specific questions with which I hope the Commission will concern itself are: . . . the desirability of establishing a series of intermediate technical institutes."

Likewise, President Conant of Harvard University, on page 5 of his 1946 report to the Board of Overseers said, in part, "For many types of students a terminal two-year education beyond the high school, provided locally, seems better adapted to their needs than that offered by a traditional four-year residential college. The difference in cost between the two, of course, is very large. Many who have studied the problem intensively feel that the further demands for advanced education should be met largely by the rapid expansion and development of such terminal two-year colleges."

From the two foregoing statements it would appear that the technical institute is coming to be recognized as a type of institution which has an extremely significant part to play in the educational system of the country.

Efficient Fuel Utilization

A PROGRAM of co-operative research and engineering for the petroleum and automotive industries which would lead to greater fuel economy in motor-vehicle operation with a resultant great saving of petroleum reserves as well as a one-third reduction in the cost of automobile transportation, was outlined by C. F. Kettering, member A.S.M.E., vice-president in charge of research, General Motors Corporation, in a paper delivered during the summer meeting of the Society of Automotive Engineers, at French Lick, Ind., June 4, 1947.

Mr. Kettering said that the key to higher efficiencies in internal-combustion engines, thus resulting in substantial savings in fuel, is in the increase of the compression ratio.

At present Diesel engines are operating with a range of compression ratios between 14 and 17 to 1 and with brake thermal efficiencies as high as 38 per cent. If equivalent compression ratios can be used in spark-ignition engines, the same full-throttle brake thermal efficiencies should be obtained. The reason automobile engines are in the range of about 6½ to 1 compression ratio with a maximum of about 25 per cent thermal efficiency is because engines and fuels have not yet been adequately matched.

However, through the use of triptane, one of the best fuels known from the standpoint of knock, it has been possible to build experimental high-compression spark-ignition engines which give as high efficiency as Diesel engines and without knock.

A single-cylinder engine of 30-cu-in. displacement was built to explore the range of compression ratios beginning at approximately 6 to 1 and extending up to 15 to 1. The engine was designed to give the required strength and rigidity for compression ratios up to 15 to 1, otherwise the engine was conventional in design. The compression ratio was varied from 6.2 to 1 to 15 to 1 in five steps by changes in pistons. The purpose of this single-cylinder-engine program was to obtain basic data on the effects of compression ratio on performance and efficiency.

The tests on the high-compression single-cylinder engine plus Diesel experience gave the basic data for designing and building a 6-cylinder engine which could be installed in a car. The compression ratio chosen was 12.5 because the single-

cylinder data had shown that most of the gains in efficiency on this cylinder construction could be obtained at this ratio.

To give a good base line for comparison, a standard 1946 production car was chosen. The displacement of the high-compression engine was selected in accordance with the single-cylinder test so that it would deliver approximately the same horsepower throughout the speed range as the standard comparison engine. It was also designed to be readily interchangeable with the standard engine so that it could be installed in the car without difficulty. With approximately the same horsepower, the same axle ratio, and the same weight, the two cars should have equal performance. No weight limitation was placed on the design of the high-compression engine.

While it was planned to use triptane as fuel for the early work on the six-cylinder engine, a compression ratio high enough to require triptane was not used. The ratio was chosen to obtain the greatest practical part of the gains of high compression ratio as indicated by the single-cylinder tests.

The engine was designed according to conventional procedures except that it was made rigid enough to carry the higher loads imposed. Diesel experience helped greatly on this problem because the stresses involved are comparable. After it was found that there were no special difficulties from roughness and high friction on the first experimental engine, a second experimental design following conventional practice was made. This new engine was designed from experience in the high-compression project on both the single and original 6-cylinder engine and weighs no more per horsepower than stock engines.

Dynamometer tests of the full-throttle corrected power, brake mean effective pressure, and volumetric efficiency for the high-compression engine and the 1946 stock-production engine were made. The horsepower of the two engines was comparable. The brake mean effective pressure was much higher on the high-compression engine at all speeds. Volumetric efficiency of the high-compression engine was as good or better than the stock engine at all speeds, showing that there is no restriction to engine breathing. The large gains in brake mean effective pressure are a measure of the gains in specific output. The stock engine had a maximum brake mean effective pressure of 109 psi at 1250 rpm and the high-compression engine had a maximum brake mean effective pressure of 130 psi at 1750 rpm.

Further comparisons of the full-throttle performance of the two engines revealed that both friction mean effective pressure and mechanical efficiency improved on the high-compression engine. This shows that it is possible to design a high-compression engine without excessive friction.

A minimum specific fuel consumption of less than 0.40 lb of fuel per bhp-hr in comparison with 0.54 for the stock engine was obtained, a gain of about 35 per cent. Both types of engines gave high full-load fuel economies.

Throughout the speed range the high-compression engine lost less heat per horsepower through the exhaust and cooling water, and more was utilized in producing power. Heat rejection for the high-compression engine was almost 30 per cent lower than for the stock-production engine.

The six-cylinder high-compression engine was then installed in one of two of the same model stock automobiles. These two cars have been run on comparative road tests for many months and both give normal smooth operation. A short drive in the high-compression car shows that the performance and feel are just about the same as a production car, and it is impossible to tell from driving the two cars which one is which, except at high speeds where the high-compression car is somewhat faster. It should be remembered that the output of the high-compression engine was made to match the same performance as the standard engine. The factor that cannot be demonstrated on a short run in the car is the greatly increased economy.

A comparison of constant-speed level-road economy of the high-compression and standard cars shows that the high-compression car gives from 35 to 40 per cent better economy in miles per gallon than the standard car. At 40 mph the standard car has a fuel economy of 18.5 mpg while the 12.5 compression-ratio car has an economy of 26.5 mpg, an improvement of approximately 40 per cent. At 60 mph the saving is 35 per cent. While these data are important from an engineering standpoint, they give only part of the story because automobiles are not driven on level roads at constant speed very much of the time. Approximately two thirds of the gasoline is consumed in city driving where a large percentage of the operation is transient and requires the entire throttle range of the engine.

In order to determine the actual gain in economy a number of cross-country trips were made where both cars were driven together under the same speed and traffic conditions. On a large number of such trips under widely varying road conditions the average gain in economy was about 33 per cent. Where the maximum speed was held below 50 mph the gain was 35 per cent. In the same test made with the maximum speed limited to 70 mph, the gain was 33 per cent. Several extended trips made entirely in city traffic show gains of more than 40 per cent, which is of major importance in view of the large quantity of fuel burned under these conditions.

The experimental test fuel used was a sensitive type of gasoline which was produced by catalytic cracking, and with 1.5 milliliters of tetraethyl lead, had a research octane number of 99 and an A.S.T.M. octane number of 85. It is understood that such a fuel could be made and sold in large quantities at a comparatively small premium.

Mr. Kettering added that these engines and fuel developments are in the laboratory stage and how soon they can be incorporated in the automobile will depend upon a large amount of development by both the automobile and petroleum industries working toward a common goal. The jump from present engines to high-compression engines can only be taken in steps. As the petroleum industry makes an improvement in fuels the automobile industry can supply a higher-compression engine to utilize them.

High-Speed Camera

A CAMERA with a speed of one millionth of a second which produces a finished photographic projection within 30 sec after the picture is taken has been developed by the General Electric Company, Schenectady, N. Y.

The camera, being two feet long and one foot high and deep, is not portable and is not intended for use by the camera fan. Fully automatic with the press of a button, it is part of equipment developed for the rapid testing, by means of electric power surges, of apparatus used in the generation and transmission of electric power. Such tests are made to determine insulation characteristics of new designs and to assure that equipment under production meets performance specifications.

Used in combination with a cathode-ray oscillograph, the camera photographs a visual indication which appears on the television-like screen when a surge of high-voltage electric power is applied to the equipment under test. Since the total duration of the recorded voltage wave may be as short as one millionth to a few hundred millionths of a second, the camera speed must be exceptionally high.

As soon as the photograph is taken, the operator pushes a button, thereby setting into action the automatic developing equipment built into the camera. The development cycle is

finished in 24 sec and the film is moved into another compartment in which a projector reproduces the negative, enlarged about ten times, on a ground-glass screen at one side of the camera. This picture gives the operator an accurate record of the performance of the equipment during the application of the surge.

It was pointed out that the time saved by the high-speed camera is significant because of the large investment involved in the equipment being tested, the oscillograph, and the associated test set, a generator which produces surges of up to 3,000,000 volts. With this new equipment it is estimated that testing of electric apparatus will be speeded up as much as ten times.

Beta-Ray Spectrometer

AN improved magnetic lens beta-ray spectrometer has been constructed at the National Bureau of Standards for use in research on the behavior of radioactive isotopes. The beta-ray spectrometer is one of the most valuable instruments for the study of beta particles and gamma rays, which are important manifestations of nuclear radiation.

As a result of recent developments in atomic energy, radioactive isotopes—of which there are about 400—are becoming available in increasing quantities, and their field of usefulness is spreading rapidly not only in physics and chemistry, but also in medicine, biology, and industry. The fundamental requirement for such expansion, however, is accurate information concerning the properties of these radioactive elements and the quality of their radiation. Following this, information must be available relating to the chemical and biological behavior of these elements with respect to proposed uses. For example, radioactive isotopes which in themselves are strongly toxic to a biological organism could not be used as a tracer for studies with that organism.

The first use of the beta-ray spectrometer at the Bureau is the current study of the energies of beta and gamma rays emitted by radio elements. The gamma rays emitted by an element, if they have the proper energy, will have a penetration that may prove particularly helpful in medical treatments and radiography. Similarly, the use of a particular isotope as a radioactive tracer in many fields of research is dependent upon information regarding the penetrating power of the beta rays given off.

Investigations of the energies of the gamma and beta rays, together with other work on radioactive isotopes now being performed at the Bureau, are expected to contribute to a number of important results, including the development of general standard methods for preparing radioelements for use as tracers; the evaluation of techniques of measuring radioactivity; the preparation of standard samples; and the accumulation of a body of data helpful in providing guidance in the interpretation of laboratory and clinical results.

In a manner similar to that by which a glass lens forms an image with visible light, the magnetic lens in the beta-ray spectrometer forms an image with electrons emitted from a radioactive source. The position of this image depends upon the speed with which the electrons are ejected from the source. Thus there may be obtained on a Geiger-counter detector a series of images whose positions are determined by the speed or energies of the electrons thrown off by a particular substance. This establishes the energies of the beta rays emitted.

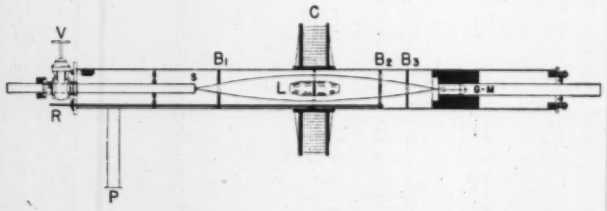


FIG. 7 LONGITUDINAL SECTION OF THE THIN MAGNETIC-LENS BETA-RAY SPECTROMETER

(Radioactive source *S*; Geiger-Müller counter *G-M*; magnetic coil *C*; series of baffles B_1, B_2, and B_3; heavy lead baffle *L*; gate valve *V*; pump *P*.)

Gamma rays usually occur as the accompaniment of beta radiation. However, since they are purely an energy radiation, they cannot be tracked on a detector and must be studied indirectly. This is possible through observation of velocities of electrons ejected from the atoms of a heavy metal when a gamma-ray collides with an electron. With the use of a correction factor for the energy lost at the time of impact, the gamma-ray energy may be successfully computed.

The spectrometer tube consists of a cylindrical vacuum chamber, see Fig. 7. At one end of the axis of the chamber is mounted a source of radioactive material *S*; at the other end is a thin-window Geiger-Müller counter *G-M* which acts as a detector. The electrons travel down the spectrometer tube, restricted in their paths by a set of baffles B_1, B_2, B_3 and are focused upon the detector by the lens coil *C* mounted coaxially with the chamber. The heavy lead baffle *L* at the center of the lens shields the counter from gamma rays that may be emitted from the source and from the beta rays traveling down the axis of the tube.

The vacuum chamber is a brass tube $6\frac{1}{2}$ in. in outside diameter, $\frac{1}{2}$ in. in wall thickness, and about $6\frac{1}{2}$ ft in length. The ends are sealed with grooved circular plates and rubber gaskets. An opening through one end plate is provided with a Wilson seal, through which passes a $1\frac{1}{2}$-in. brass tube for support of the radioactive source. A gate valve *V* at this end, with a small chamber that can be evacuated, furnishes a means for inserting or removing sources of radiation without destroying the vacuum in the main chamber. The vacuum within the spectrometer is produced by pump *P*.

An opening in the other end plate of the main chamber is also equipped with a Wilson seal to accommodate a 2-in. brass tube, in which the Geiger-Müller counter is mounted. The position of the detector can thus be adjusted without breaking the vacuum in the spectrometer chamber.

Investigation of the penetrating power of beta and gamma rays has its most immediate application in medical and biological research. However, knowledge of nuclear structure is advanced considerably by accurate information concerning relative energies. At the present time, a clear explanation of beta-ray phenomena remains one of the critical problems in modern physics.

Tubeless Tires

TUBELESS tires, goal of tire manufacturers since the opening of the automotive era, have been developed by The B. F. Goodrich Company, Akron, Ohio, and are now undergoing all known tire tests, it was announced recently.

The new tire, perfected after more than three years of engineering, combines the safety features of puncture-sealing inner tubes with improved riding qualities, high-bruise resistance, and remarkable ability to retain air pressure. The tubeless tire embodies rayon-cord construction.

In addition to a high-speed road-testing program in the Southwest, tubeless tires are in service on a taxicab fleet in a Midwestern city, on state police cars, and a number of privately owned passenger cars.

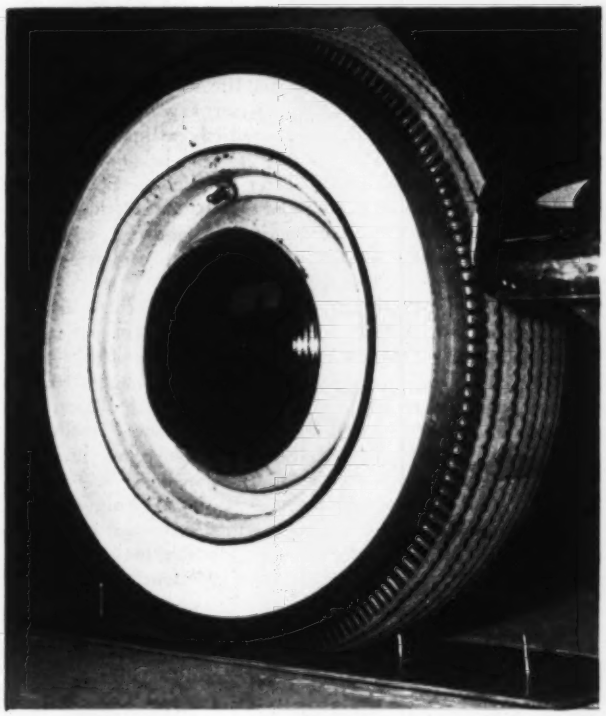


FIG. 8 PUNCTURE-SEALING QUALITIES OF THE TUBELESS TIRE ARE DEMONSTRATED BY DRIVING IT OVER SPIKES

The tubeless tire will be offered only for limited sale at this time, the company stated. Applications have been filed with the United States Patent Office.

Army Engineer Laboratories

THE Engineer Board of the Engineer Research and Development Laboratories, Fort Belvoir, Va., conducted its annual Open House for interested members of the Armed Forces and science and industry on May 7, 1947. New items of equipment which the Engineers have been working on for the past year were exhibited and the facilities for carrying out an extensive research and development program were displayed. Approximately 525 persons attended.

HISTORY AND PROGRAM

The basic purpose of the Engineer Research and Development Laboratories is to adapt commercial engineer equipment for use by the Army, to develop new equipment for special uses, and to evolve methods for putting this equipment to work.

The program for carrying out this mission is accomplished by the Laboratories under the supervision of the Engineer Board. This Board, which has been situated at Fort Belvoir since 1921, is a lineal descendant of a series of special boards, dating back to before 1888, established by the Corps of Engineers to develop or modify equipment.

The technical activities of the Laboratories embrace applied research, development, and testing. Wherever possible, research necessary for the development of Engineer equipment is accomplished through contracts with educational institutions, research foundations, and the laboratories of American industry. However, in order to test the products of these organizations and to accomplish the necessary work that they are not able to undertake, the Laboratories must maintain facilities to serve a wide range of engineering and scientific activity. These facilities provide the project engineers and scientists with the tools necessary to translate the military characteristics supplied by using agencies into satisfactory military equipment.

The development program upon which the Laboratories are now engaged is the result of a painstaking and thorough survey of the performance of American and foreign military equipment during the past war. On the basis of these studies, and of the trends made inevitable by the advent of such unorthodox weapons as the atom bomb and rocket-propelled missiles, the types and capabilities of Engineer equipment for the postwar Army were determined by the Corps of Engineers, Army Ground Forces, and Army Air Forces, and were approved by the War Department General Staff.

While specific characteristics are set forth for each of the many items of equipment under development, certain general requirements have also been established. In general, the equipment being developed under the present program is being designed for air transportation, a factor which involves extensive use of lightweight alloys and plastics, and it is to be capable of operating in wet, dry, and Arctic climates.

Wherever possible, the program is taking advantage of the continued trend toward greater mechanization to supplement and increase the effective man power of the Army.

Brief descriptions of some of the laboratories and facilities at Fort Belvoir which the U. S. Army Engineers use to conduct research and which were open for inspection during the annual Open House follow.

LABORATORIES

The Mapping Laboratories contain extensive facilities for developing equipment and methods for all phases of military mapping. These include the compilation of planimetric and topographic maps, mosaics, and photomaps from aerial photography; and the photographic and lithographic reproduction of maps, charts, mosaics, and photomaps.

A collimating room for surveying instruments, a repair shop, and museum are maintained in another building. The museum is the most complete known to exist. Practically every country producing such instruments is represented in this collection. It also contains numerous items which are unique or mark significant steps in the development of modern surveying.

In the Electronics Laboratory, the development of detectors of metallic and nonmetallic mines has led to the use of equipment utilizing electromagnetic radiation at frequencies from the audible range (1 to 20,000 cycles per sec.) to the microwave and gamma-ray range (10^{20} or 100,000,000,000,000,000,000 cycles per sec). The Electronics Laboratory is equipped with precision instruments for the electronic measurement of phenomena occurring in this range of frequencies as part of its research into the electrical and magnetic characteristics of soils and the accurate analysis of developed detection systems.

The Radiation Laboratory contains complete optical and electronic test apparatus for infrared research and development and for the testing of infrared viewing and detecting devices and their individual components. This equipment includes instrumentation for measuring the sensitivity and response of infrared and electron-sensitive phosphors, photoemissive materials, and infrared image tubes; spectrophotometers and monochromators for measuring the spectral properties of optical materials and the spectral response of photocells; comparators for determining the visual security of near-infrared filters; test apparatus for measuring the sensitivity and responsivity of heat-sensitive elements; and electronic-photo-

metric test sets for measuring the performance of image tubes while under shock test.

The Optical Shop contains facilities for grinding and polishing small optical elements, including lenses, prisms, and mirrors. It is especially equipped for working the synthetic crystals which are utilized in infrared equipment because of their transparency to long-wave-length radiation. In the shop, new techniques for producing optical elements from these crystals are being developed, and experimental optics from standard materials are being produced or modified.

In addition to testing the various materials used in the Corps of Engineers equipment, the Materials Laboratories conduct research and development on such items as rubber, plastics, synthetic crystals, fungicides, metals and alloys, protective coatings, coated fabrics, and adhesives.

Of particular interest is the Temperature Test Laboratory which provides facilities for testing Army equipment under extreme climatic conditions. In addition to the tropical testing chamber, two other test chambers are provided. In these, atmospheric conditions of the tropics, deserts, high mountains, and the Arctic can be accurately simulated. These facilities, the large and small test chambers, are designed to permit full operation of internal-combustion engines, electric generators, and other mechanical and electrical equipment.

The main test chamber provides for the testing of any equipment, weighing 23 tons or less, which can be set up within a working space 14 ft wide, 32 ft long, and 13 ft high. Equipment on test may be subjected to temperatures of from plus 150 to minus 70 F, relative humidities of from 20 to 100 per cent, and altitude conditions varying from sea level to 25,000 ft. Fog, dew, and frost conditions can be obtained; and, by setting up special devices in the chamber, heavy rainfall and high wind velocities may be imposed on the tested equipment. Connections are installed in the chamber walls to conduct liquids or gases to or from the test unit.

Other laboratories include: Water Supply, Distillation Testing, Electrical Testing, Reflector Research, Illuminating Engineering, Mechanical Equipment Testing, Processing and Packing, and Motion Picture.

A number of shops are maintained to serve all phases of the work of the laboratories, and to expedite the construction or maintenance of experimental models, testing equipment, and laboratory instruments. These facilities include a machine shop, foundry, welding shop, sheet-metal shop, woodworking and pattern shop, paint shop, model shop, and automotive shop.

TEST AREAS

While the major part of the testing of bridging equipage is carried on at the Yuma Test Station in Arizona, facilities are maintained at the Ponton Basin Area at Fort Belvoir for limited testing of boats, motors, pontons, rafts and other similar equipage.

The tanks, pipe-line, and pumping systems maintained for the development and testing of petroleum-distribution equipment are also located in the Ponton Basin area. Approximately 100,000 gal of high-octane aviation gasoline, stored in the tanks, may be circulated through the pipe-line system for tests of newly developed pipe-line equipment and components. Pumping units and engines are tested on individual stands with separate 100-barrel tanks. This arrangement permits the testing of as many as 20 units simultaneously. The installation is equipped for testing all phases of petroleum distribution, including pipe-line and dispensing pumping units; pipe, hose, and fittings; valves; and steel, aluminum, and fabric storage tanks and containers. Among the developments tested at this installation are a 2-stage centrifugal pipe-line pumping unit, which replaced a conventional reciprocating pumping unit of three times its weight; and roto exhaust valves, which permit pumping engines to use high-octane gasoline directly from the lines thus greatly prolonging engine life.

In a special demonstration the visitors saw how a pipe-line is laid by helicopter in remote areas which ordinarily would be difficult to approach.

The Engineer Board Field, better known as "Eebee Field," embraces areas for engineering and operational testing of earth-moving, land-clearing, and materials-handling equipment; special vehicles and trailers; power tools; and fire-fighting equipment, materials, and techniques.

Eebee Field is divided into two test sections, the operational test section, which embraces all testing except fire-fighting equipment, and the fire-equipment test section.

The Demolition Test Area is maintained adjacent to Eebee Field for the purpose of testing new items of demolition equipment and of techniques for their employment. It comprises approximately 325 acres of land, of which approximately 30 acres are cleared for test sites.

Within this area are four major explosives-testing sites. The area contains three explosives magazines, a laboratory building, and a blastproof observation shelter, all of permanent-type construction. The area is equipped with sufficient test facilities to test all standard and experimental items containing up to 1000 lb of explosives.

As part of the program, the visiting guests witnessed the firing of an M-3 demolition snake.

Included on the program was a display by manufacturers of some of the newest items of mechanical equipment such as saws, compressed-air equipment, and earth-moving equipment.

Largest All-Jet Airplane

THE Martin XB-48, said to be the largest multijet bomber of conventional design ever built, is briefly described in *The Martin Star*, May, 1947.

The new airplane, built for the Army Air Forces, is a long-range, high-speed bomber, powered by six General Electric gas-turbine engines, housed three in each wing. The first conventional bomber with more than four jet engines, the XB-48 will boast 24,000 lb of thrust a maximum power greater than that of two giant electric railroad engines each pulling a string of 125 freight cars.

Because of the thin wings required for its exceptionally high speeds, the XB-48 is pioneering a new "bicycle type" landing gear especially designed for airplanes flying at speeds approaching the trans-sonic.

Just fourteen months were required to complete the XB-48, from first engineering work on the plane until it was wheeled from the airport to begin its ground testing—a full year cut from the normal development time of a new military airplane.

The new A.A.F. bomber has a wing span of 108 ft, 4 in.; length of 85 ft, 9 in.; height of 27 ft, 6 in. The wings are of a special design.

As the wings are thinner than in an airplane built for slower speeds, there is not sufficient space to house the large main wheels required for safe landings and take-offs. In the XB-48 the two main wheels are placed bicycle style in the center of the ship and retract upward into the fuselage. A smaller wheel is located near each wing tip to give stability during taxi operations. These retract into shallow wells in the wings.

The company has been experimenting for some time with the tandem-type landing gear, having equipped a B-26 Marauder with the main wheels in the fuselage and outrigger-type balancing wheels. Numerous landings and take-offs have been

made at both Martin Airport and the A.A.F.'s Wright Field, Dayton, Ohio. These have proved the worth and stability of the design for airplanes of extremely high speeds.

Investigation of Welded Ships

THE final report of a Board of Investigation convened by order of the Secretary of the Navy in April, 1943, to inquire into "The Design and Methods of Construction of Welded Steel Merchant Vessels," has been released recently by the Ship Structure Committee, United States Coast Guard, Washington, D. C.

The report summarizes the results of the investigation into the epidemic of structural failures of welded-steel merchant vessels occurring early in the war.

The seriousness of this structural-failure problem may be gaged by the fact that out of approximately 5000 ships constructed in the course of the war, about one fifth sustained casualties. Of these casualties, 127 were classified as serious. Eight vessels were lost but only 26 persons lost their lives. Contrary to widespread belief, the fracture menace did not confine itself to Liberty Ships but involved vessels of all types.

During the course of the investigation many research projects were initiated under the National Defense Research Committee. These projects were carried out with the services of the Welding Group of the War Metallurgy Committee at the National Research Council. In utilizing the facilities of the War Metallurgy Committee, the board was able to bring to bear on its problems some of the best scientific minds in the country. Through a complete co-ordination of effort in research, results were obtained in a minimum of time. Close liaison was maintained throughout the investigation with the British and with other Allied Nations who were concerned with the operation of welded merchant vessels.

The over-all designs of merchant vessels were checked by recalculation of the longitudinal strength and by means of static structural tests on certain vessels. It was found that there was a margin of strength in every case over that required by existing standards and that the basic analytical method used in calculating the strength of the hull girder is valid.

In the investigation of detail design, it became apparent that the monolithic character of the welded ship resulting from the method of fabrication can produce high stress concentrations and severe restraint, thereby tending to inhibit plastic flow. This condition did not exist generally in the riveted ship. The danger of high concentration at points of structural discontinuities in the welded ship is further aggravated by welding usually present at such points. Every fracture examined started in a geometric discontinuity or notch resulting from unsuitable design or poor workmanship.

The investigation pertaining to structural details has strongly emphasized that too much attention cannot be paid to the elimination of discontinuities or notches, whether they be small or large, and that the effect of discontinuities is aggravated by welding.

Studies indicated that steel as furnished to shipyards complied in every respect with present physical requirements. In spite of this, impact tests of steel samples taken from vessels which had suffered fractures indicated that in many cases the steel was notch-sensitive. In addition, it was found that some steels furnished to shipyards were also notch-sensitive. There is a necessity for the establishment of a new specification to include a practical test for the evaluation of the notch sensitivity of commercial steels.

There is no indication that inferior quality or misapplication of welding electrodes was responsible for welded-ship fractures. This does not mean, however, that an improvement in electrodes and covering materials might not be beneficial.

The use of welding in the construction of merchant vessels during the war permitted the launching of an enormous fleet of ships which played a vital part in the winning of the war. There are, however, certain disadvantages connected with welding which were not fully realized at the outset. Although the technique of depositing weld metal and the application of welding sequences to minimize shrinkage, distortion, and cracking were fairly well understood, relatively little was known of deleterious conditions accompanying the welding processes on large ship structures. Consequently, when fractures in all-welded steel merchant vessels first began to manifest themselves, conditions were found which did not conform to previous experience. There was a general feeling that the accelerated shipbuilding program and the concomitant quantity production of all-welded ships had resulted in a general disregard for proper construction procedures and workmanship. It was particularly felt that insufficient care was being devoted to welding sequences with the result that locked-in stresses were present in many ships to a higher degree than would be expected. The presence of these higher stresses was believed to be an important factor in the incidence of the observed fractures. The results of the investigation, however, have not substantiated this belief.

Although a large amount of work was conducted in the investigation of residual and locked-in stresses resulting in a considerable extension of knowledge in this respect, no evidence has been found to indicate that these stresses are important in causing the fractures of welded ships.

The feeling that workmanship had suffered due to the pressure of wartime production programs was substantiated. The importance of maintaining adequate standards of workmanship has been clearly established by the analysis of structural failures in the last three years. Poor workmanship engenders fractures since a fracture may originate at a small notch such as occasioned by peened-over cracks and undercut welds, by porosity and inclusions in the welds, or by "saddle" welds resulting from incomplete penetration, which leaves voids in the center of the joints. High-quality workmanship is still an important need in the building of welded ships.

A study of operating conditions resulted in the finding that loading and ballasting procedures did not create abnormal bending moments.

The wartime operation of cargo ships in convoys and overseas routes which are used infrequently in normal times imposed unusual hardships on the vessels, especially during the early part of the war when convoys were being routed through extremely cold waters where heavy seas prevailed during the winter months. The highest incidence of fractures occurred under the combination of low temperatures and heavy seas. The risks involved were accepted as far as heavy seas were concerned, but at the start the adverse effects of low temperature were not fully appreciated. When these facts were recognized, vessels modified to increase their resistance to fracture were assigned to the more rigorous trade routes.

The board concluded that the fractures in welded ships were caused by notches built into the vessels, either through design or as the result of workmanship practices, and by steel which was notch-sensitive at operating temperatures. When an adverse combination of these factors occurs, the ship may be unable to resist the bending moments of normal service.

The serious epidemic of fractures in the steel structures of welded merchant vessels has been curbed through the combined effect of the corrective measures taken on the structure of ships during construction and after completion, improvements in design, and improved construction practices in shipyards.

The results of the investigation have vindicated the all-welded ship. Statistics show that the percentage of ships sustaining serious fracture is small. With proper detail design, high-quality workmanship, and a steel which has low notch sensitivity at operating temperatures, a satisfactory all-welded ship structure may be obtained.

However, until experience can be had with vessels constructed under normal conditions of improved design, materials, and workmanship, some form of crack arrester such as a riveted gunwale angle should be incorporated in the hull girder of all large welded vessels.

Copies of the complete report may be obtained from the Secretary, Ship Structure Committee, Washington 25, D. C.

Underground Factories

ON the basis of an investigation of the feasibility of underground factories as an effective means of protecting production from enemy air attacks, made by the Air Materiél Command analysts at Wright Field, Ohio, the Army Air Forces has learned that one of the paramount requirements of an underground factory is to have a broad segment of supporting and related activities within the underground site.

Experience of the Germans proved that if surface transportation were weakened and the deliveries of war materials to factories were prevented, the condition of the factories would make little difference. Similarly, bombing of electric-power systems could render production facilities useless.

The Germans did not have the opportunity to place underground the full range of supporting activities such as power plants, transportation systems, forges, and others. There is also little evidence of instances where workers' housing was located underground.

Electric power was generally furnished by existing local facilities, and transformed to the desired voltage by underground transformer stations. Three underground generating stations were reported in the Clausthal grid, near Clausthal, Germany, which supplied power to mines and towns in the area.

In locating steam plants underground, the Germans were confronted with the big problem of supplying fuel. Generally, it was necessary to obtain gas or coal from outside sources, which involved using a transportation system vulnerable to air attack.

Evidence of the paralyzing effects upon plant production obtained by bombing power installations rather than the production area itself was demonstrated in the attacks on the Krupp plant. Attacks on the target itself succeeded in curtailing production only 30 per cent. However, destruction of power-generating and distributing facilities resulted in a virtual complete shutdown of plant operations.

German experience proved that underground storage of raw materials and finished goods should be provided to enable the factory to operate for at least two weeks without the need for new deliveries. This would provide some degree of insurance against interrupted surface transportation facilities.

Officials of Air Materiél Command say that it is difficult to list all the operations associated with the manufacture of the final product that should be placed underground in order to preserve continuing production. The Germans realized the importance of moving these associated operations underground, but insufficient time, money, and resources prevented the adoption of these remedial measures.

German officials have stated that the increased difficulties which have been created by moving additional manufacturing operations underground would have been more than compensated for by the increased security against bombing attacks.

Aluminum From Clay

WARTIME research at the National Bureau of Standards has resulted in the development of two processes for producing aluminum from clay—one a hydrochloric-acid extraction process, the other an alkaline extraction with a solution consisting of a mixture of sodium hydroxide and sodium chloride. Thus clay may sometime replace bauxite as a source of the metal.

HYDROCHLORIC-ACID PROCESS

While the hydrochloric-acid process is applicable to nearly all clays, kaolin was used in the pilot plant constructed by the Bureau because of its abundance and accessibility. The raw material first enters a triple-hearth Wedge furnace, where it is roasted at about 700 C to increase the solubility of its alumina content in acid. It then passes into a digester, in which it is stirred to mix with hot dilute hydrochloric acid until soluble material is dissolved. For commercial operation, digestion for one hour at about 100 C is sufficient. The slurry in the digester is then cooled to about 60 C by turning off the steam and circulating cooling water through the heaters.

From the digester the cooled slurry is pumped into a filter

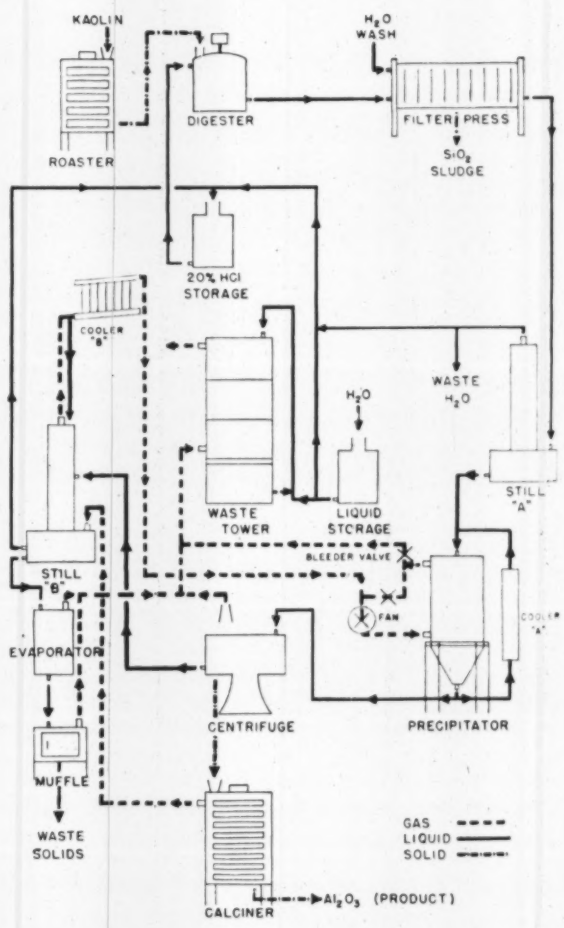


FIG. 9 FLOW SHEET SHOWING THE HYDROCHLORIC-ACID PROCESS FOR PRODUCING ALUMINUM FROM CLAY

press where the insoluble matter, consisting largely of silica sludge is removed. After all of the slurry is pumped into the press, the filter cake is blown dry with compressed air and then washed with water. The acid filtrate and washings pass into a still in which the solution is evaporated to a relatively small volume to minimize the quantity of hydrochloric-acid gas required in the next step to precipitate the aluminum as the hydrated chloride ($AlCl_3.6H_2O$). The water distillate is discarded, while the acid distillate is retained for future decomposition of clay in the digester.

The concentrated solution is then cooled and enters a precipitator, where intimate contact with hydrochloric-acid gas results in the precipitation of the hydrated aluminum chloride. This is accomplished by pumping the solution to the top of an unpacked tower, where it is allowed to fall against a stream of hydrochloric-acid gas entering below. Because of the heat involved in the absorption of the hydrochloric-acid gas, the solution is circulated through a cooler during the process to increase the absorption rate. From the precipitator, the aluminum chloride, suspended in a solution saturated with hydrochloric acid, goes to a rubber-coated centrifuge with perforated basket, where the chloride crystals are removed from the solution by filtration through an asbestos cloth. Impurities adhering to the aluminum chloride are removed by washing with a hydrochloric-acid spray.

Conversion of the hydrated aluminum chloride to the oxide is accomplished by calcination in a muffle-fired furnace with constant agitation of the aluminum chloride by the rabble arms as it passes downward over the heated hearths. This agitation makes the conversion of chloride to oxide a continuous process and effects the conversion at a lower temperature than would otherwise be necessary. A rubber-coated exhaust fan pulls the hydrochloric-acid gas and water vapor from the top of the furnace. The acid gas is drawn through a cooler, where a certain amount of the aqueous acid condenses and is drained into a still for later generation of hydrochloric-acid gas used in the process. The major portion of the acid gas, after passing through the cooler, is absorbed in cool hydrochloric acid of constant boiling strength in an absorption tower by the same technique as that used in the precipitation of aluminum chloride. In this way the constant boiling acid is built up to acid of specific gravity 1.18 to 1.20, which is then pumped into a still and heated to produce hydrochloric-acid gas for precipitation of aluminum chloride. The alumina emerging from the bottom of the furnace is removed by a vibrating conveyer so arranged and regulated that the lower end of a 6-in. glass outlet pipe is always filled with oxide. This prevents air from entering the furnace and diluting the hydrochloric-acid gas issuing from the top.

The alumina obtained by this method has an average purity of about 99.8 per cent. The only significant impurities are 0.1 per cent of chlorine, 0.04 per cent of iron oxide, and 0.06 per cent of silica. If a purer product is desired the chloride content can be further reduced by longer heating at higher temperatures, and the content of iron oxide can readily be lowered by additional washing of the chloride in the centrifuge basket.

The price of producing aluminum by the hydrochloric-acid process is at present about twice that from imported bauxite. However, studies now in progress at the Bureau may result in the reduction of the original cost figures.

ALKALINE EXTRACTION

In the process for the alkaline extraction of alumina from clay, a mixture of clay and limestone is prepared by either wet or dry process grinding and mixing. Commercial equipment is available that appears to be particularly well adapted for burning the raw mix and annealing the resulting clinker. This apparatus consists of an ordinary rotary kiln in series with a rotary cooler, the latter carrying a burner installed at its feed end. Thus the clinker discharged from the primary kiln can be annealed in the cooler at a rate determined by its speed of rotation and by adjustment of the burner. Complete dusting of the annealed clinker reduces the need of further grinding.

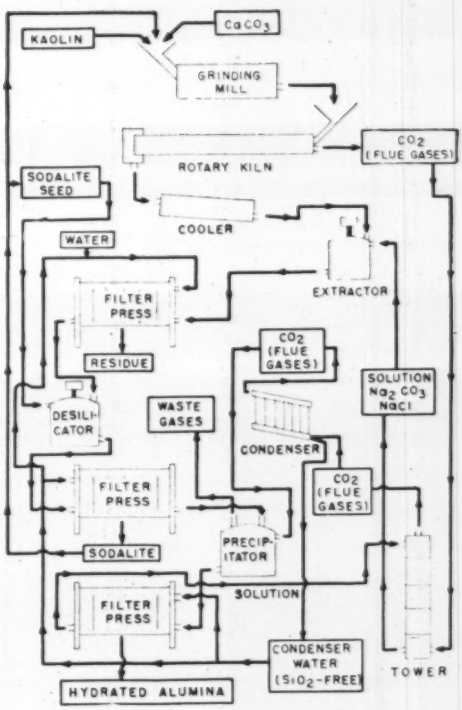


FIG. 10 FLOW SHEET ILLUSTRATING THE LIME-SINTER PROCESS FOR EXTRACTING ALUMINUM FROM CLAY

A solution of sodium carbonate and sodium chloride is added to the powdered mixture, and the resultant slurry is stirred at high speed for about one-half hour at 60 to 80 C. On completion of the extraction period, the mixture is filtered and an extract containing 70 to 80 grams of alumina and 1 to 2 grams of silica per liter is obtained. By subjecting the residue to countercurrent washing with salt solution, it is expected that the concentration of alumina in the wash water can be built up to approach that in the extract. The residue, consisting principally of lime and silica, may then be washed with water and stock-piled as a raw material for the production of Portland cement.

The filtered alumina solution plus concentrated washings is next desilicated by boiling for one hour with a seed charge of synthetic sodalite, which induces the precipitation of crystalline sodalite. After filtration, the sodalite in excess of that required for seed for the next batch is returned to the first stage of the process. In this way the alumina and soda in the excess sodalite are recovered.

Hydrated alumina is precipitated by passing carbon dioxide, obtained from scrubbed kiln gases, into the desilicated solution. In order to avoid contamination by silica, the precipitation of alumina is not carried to completion. However, in cyclical operation of the process complete recovery of the alumina from solution would be obtained. The alumina is filtered and washed with water low in silica to avoid contamination and the residual solution and washings are used to scrub the kiln flue gases. This procedure causes not only removal of dust from the gases but also evaporation of water from the combined solu-

tion and washings. Sufficient make-up quantities of sodium carbonate and sodium chloride are added to the evaporated and carbonated solution, so that it may be used for the extraction of a fresh batch of sinter. The hydrated alumina is dried and calcined for electrolytic reduction to aluminum.

About 95 per cent of the alumina in the clay is recovered by this method, while losses of soda are small. An advantage of the process is that all steps can be conducted at atmospheric pressure, whereas many other alkaline methods for the extraction of alumina require autoclave desilication.

Seamless Tubing

ACCORDING to a paper presented before the American Iron and Steel Institute recently by E. N. Sanders, the National Tube Company, a United States Steel Corporation subsidiary, is in process of building a mill at Lorain, Ohio, for the manufacture of seamless pipe and tubing in sizes below $4\frac{1}{2}$ in. outside diameter, at production rates said to be unattainable on existing conventional seamless mills, and with design features which will permit the rolling of seamless tubes of lighter walls and with dimensional tolerances not possible on the conventional or automatic seamless mills. Mr. Sanders is vice-president of operations of the National Tube Company.

The process which is being utilized in the seamless mill now under construction employs two operations entirely different in characteristics from those of the conventional process. The first is the continuous tube-rolling mill which consists of nine tandem individually powered stands of two-high grooved rolls. The rolls in the consecutive stands have their axes at 90 deg to each other. The motors driving these roll stands aggregate 8500 hp. Essentially the continuous tube-rolling mill is similar to the modern strip mill in that the product passes progressively from stand to stand. The chief difference is that the tube mill requires an internal mandrel against which the workpiece is rolled to reduce wall thickness.

This cylindrical mandrel extends entirely through the pierced billet and passes through the mill with the workpiece. In the first two roll stands the diameter of the pierced billet is reduced so that the inner surface is in substantial contact with the mandrel bar. Each of the next two stands makes a reduction in wall over a portion of the circumference, the two jointly completing the first increment of reduction. The next two stands, the fifth and sixth in this mill, make a similar complete reduction of somewhat less magnitude. The next two succeeding stands (7 and 8) are designed to effect a very slight reduction, the purpose being to planish the tube surface.

The shape of the tube which has been oval in the preceding stands is changed to circular section in the ninth stand. The rounding-up operation effected by this stand frees the inner surface of the tube from the mandrel bar to facilitate withdrawal of the mandrel. This mill will deliver pipe in 65-ft lengths at rates up to 900 fpm. The over-all wall reduction which will be made in the continuous rolling mill is approximately twice that now made in the conventional two-high mill. As a result of this increased wall reduction the productive capacity of the piercing mill has been stepped up.

The second operation, which replaces the reeling and sizing operations of the present-day seamless mill, is a tension-reducing or stretch mill. After withdrawal of the mandrel, the rolled tubes are reheated before they are processed in the tension-reducing mill. This mill, which is similar in construction to the continuous-rolling mill, consists of 16 two-high roll stands with individual stands powered by 200-hp motors. Tension reducing, which has recently been developed, is unique in that without the use of a supporting mandrel the wall thickness is diminished while the diameter is reduced. This operation differs from the conventional reducing mill in which the wall thickness of the tube is increased as the diameter is reduced. In the tension-reducing mill the tension forces to which the tube is subjected between roll stands are not only effective in reducing the wall thickness of the tube but, in addition, they are said to make possible diameter reductions in successive stands more than 20 per cent greater than can be made in the conventional mill. The faculty of permitting the entering tube wall to be maintained or reduced while large diameter reductions are being made in successive stands permits a single entering tube size to be employed for the production of all tube sizes in the size range $3\frac{1}{2}$ in. outside diameter to 0.675 in. outside diameter. This unit therefore permits production at approximately constant tonnage regardless of the diameter being produced. To insure continuous operation a second sizing mill is being provided to be utilized during roll-change periods.

The seamless unit now under construction has a rated monthly capacity of 18,000 tons and will produce seamless pipe in the size range 2 in. to 4 in. inclusive. The arrangement will allow the size range to be extended downward to include $\frac{3}{8}$ in. pipe size.

The economies provided by the continuous seamless mill will be further augmented by the latest developments in mechanized handling and machining, and by recently installed warehousing facilities which will permit each size to be produced to volume quantity. By means of this new equipment, quality seamless pipe will be produced at a cost far below present costs on conventional mills.

Plastics

PLASTICS are more a promise than a threat to the textile field, David S. Plumb, of the vinyl-resins department, Plastics Division, Monsanto Chemical Company, Springfield, Mass., said in an address before the National Textile Seminar recently. Mr. Plumb outlined the work that has been done with plastics in the textile field during the last two years, stating that this entrance of plastics into an older field has tended to follow two separate, but in many cases, parallel lines. These lines, he said, are concerned with plastic films and plastic-coated fabrics.

Statistics indicate that the yardage of plastic films and of coated textiles combined totaled about one half billion. To serve this volume there are two basic raw materials now being used for plastic films and several additional materials for fabric coating. In the plastic-film field, the materials are either vinyl chloride and its copolymers or polyethylene. In the fabric-coating field, the older materials such as nitrocellulose, rubber, oils, and alkyds are being supplemented with vinyl resins. Vinyl chloride and its copolymers make up the bulk of these coating plastics, but a second vinyl resin, vinyl butyral, has the extraordinary property of ability to form a coating over cloth, which, while being durable and effective, is practically invisible.

The vinyl butyral coatings should be of particular interest to textile men. When coated onto fabrics, the resin imparts all of the properties of other coatings, but does not impair the appearance of many printed or dyed cotton or rayon cloths to any noticeable extent. The result is a coated textile suitable for such general household uses as tablecloths, slipcovers, upholstery, bedspreads, drapery, and outdoor furniture.

The entry of plastics into the textile fields has been extremely complex and confusing, but the time is rapidly approaching when all of this activity must become more co-ordinated, logical, and orderly, and each phase can then be considered in its correct relation to the textile picture as a whole.

Foundry Advances

THE foundry industry, in common with other American industries, underwent many readjustments during the war and reconversion periods. According to an article in *Metal Progress*, May, 1947, by Charles K. Donoho, American Cast Iron Pipe Company, Birmingham, Ala., this resulted in numerous advances in mass-production methods, new uses for castings, and standardization of production techniques.

Mechanization of the foundry, such as installations of sand-handling systems, molding machinery, conveyer lines, mechanical shakeouts, improved blasting and cleaning equipment, sand-reclamation systems, continuous melting methods, and modern mechanized heat-treating equipment, constitute the most important single advance of the industry.

INSPECTION

Necessarily strict specifications for castings going into new services have required many plants to make tests and meet demands which were entirely new. This had the effect of bringing testing equipment into the foundries, as well as technicians to make and interpret the tests.

Besides testing for metal quality, inspection of the castings themselves has improved. Radiography and magnetic-particle testing have been particularly valuable in preventing the shipment of a faulty product. Proof-stressing or other simulated service tests on the castings themselves are replacing test-bar tests in many instances.

ADVANCED CASTING METHODS

The application of the lost-wax method of investment casting to produce complex engineering parts to close tolerances has proved to be a real advance. The economic applications of this method are chiefly in shapes difficult to form by any other method, or in metals which are commercially unmachinable.

Die-casting or metal-mold methods also produce parts of good finish and to close tolerances. These methods are practically the standard for many zinc-base and aluminum alloys, but are also used for large tonnages of gray-iron castings—and recently in some volume for bronze and steel castings. Metal and graphite as mold materials, instead of sand, are finding their place in mass production.

Centrifugal casting has continued to find new applications in the last few years. By centrifugal force selective pressure is exerted on freezing metal to separate the dense clean metal from the lighter slag and dross. Gray iron and bronze are favorite metals for centrifugal casting, and recently high-quality steel has been cast centrifugally, both in cylindrical shapes and into disk-shaped parts.

GRAY-IRON CASTINGS

Gray iron is by far the largest-tonnage foundry metal. As compared to steel, its lower freezing range and smaller shrinking tendency makes it one of the better casting metals. The metallurgy of cast iron is complicated by the presence of carbon in three forms—free, combined, and dissolved—which vary in their relative proportions with compositions and thermal history. The variety of types of gray iron, from bathtubs to crankshafts, makes it difficult to set down rules for gray-iron casting.

A valuable metallurgical technique for increasing the quality and consistency of gray iron is inoculation. It has been proved that the addition of a graphitizing alloy or "inoculant" to molten iron in the ladle has a stronger effect than if the same increase is made by addition of the alloy to the solid charge before melting. Useful inoculants include silicon, carbon (graphite), zirconium, calcium, aluminum, titanium, and combinations of these with or without other alloys. The principal effects of inoculation, all of which are generally beneficial, are to reduce chill and hard spots, to produce a normal flake structure of graphite in the pearlite, to reduce section sensitivity, and to increase the strength-hardness ratio.

STEEL CASTINGS

Steel for castings is melted in many types and combinations of units. A contribution to higher production during the war was made by the converter, usually in conjunction with an electric holding and refining furnace. The idea that good-quality steel cannot be made in the side-blown converter was largely dispelled. Deoxidation of molten steel for castings has also received critical attention. The melting practice and necessary deoxidation (usually with aluminum) to eliminate pinholes positively in green-sand castings have been better established.

Knowledge in the steel-castings industry about alloying and hardenability control has followed closely the remarkable developments in rolled steel. The timed water-quench has given the steel foundryman a practical heat-treatment for the mass production of quality parts. The control of hardenability by composition and its quick determination by the end-quench test, together with the segregation (for heat treating) of castings of like section, the timed water-quench followed by an air-cool or immediate tempering, can produce uniformly hardened and tempered structures without danger of cracking, even when the shapes are quite complex.

In steel founding the general recognition and application of the principle of "controlled directional solidification" has produced radiographically sound castings consistently. Through recognition of the fact that shrinkage must inevitably occur when molten steel is poured into a mold, the problem is resolved into arranging the gates and risers so that risers are the last to freeze and the shrinkage occurs outside the useful part of the casting.

A thin, flat core with a small aperture at the junction of riser and casting is useful to facilitate riser removal and to reduce grinding costs. For a given core thickness the diameter of the opening must be larger than a certain critical diameter to obtain proper feeding of molten metal from the riser. The dimensional relations necessary for proper functioning of such necked-down risers have now been soundly established.

MALLEABLE AND NONFERROUS CASTINGS

Malleable-iron metallurgy is tending toward lower carbon contents, many analyses approaching those of graphitic steel. This increases both strength and ductility—a concomitant trend peculiar to malleable iron. Continuous annealing equipment gives better control of heat-treatment and shorter annealing cycles. The very interesting properties of the pearlitic malleables are being exploited commercially on an increasingly large scale. During the war the combination of toughness and machinability of malleable-iron castings was rediscovered for ordnance parts where fast machining was a prime requisite.

Iron much higher than ordinary in silicon content can be cast white in metal molds, with consequent shortening of the annealing cycle. An austenitic malleable iron, cupola-melted and die-cast, shows interesting possibilities.

In brass and bronze foundries melting practice to produce gas-free metal has been studied intensively. Centrifugal casting has also been highly developed for bronzes to produce bearings and bushings of superior properties and soundness.

Aluminum and magnesium casting increased tremendously in quantity during the war and opened up a vast new phase of the foundry industry.

Supersonic Wind Tunnel

A NEW type of supersonic wind tunnel designed to test the aerodynamic characteristics of burning ramjet motors and other rocket-type motors, will be built under the supervision of the Army Corps of Engineers at the California Institute of Technology, Burbank, Calif., the War Department announced recently. The new tunnel, for which the expenditure of $2,384,000 has been authorized, will be the first of its kind in the United States.

Because no other wind tunnel in the United States is designed for the testing of missiles with motors operating, and because the design is radically new, requiring fundamental knowledge of the problems involved, the District Engineer at the Los Angeles, Calif., Engineer District, who will have direct control of construction, will have the advice and assistance of the Institute's scientists on the project. He will also have the advice of the Army Air Forces, the Ordnance Department, and the Navy, who will be the principal using agencies.

Located in a special building 50 × 150 ft in size, the testing section of the tunnel will consist of a flexible nozzle with a cross section 15 × 20 in. With this nozzle it will be possible to test models large enough to include actual combustion, that is, up to $2^1/_2$ to 3 in. in diameter. Powered by three motor-driven air compressors each powered with a 4000-hp motor and capable of producing a combined total of 171,000 cu ft of air per min, it will be possible to develop an air velocity of 3600 mph.

An aftercooler and auxiliary piping and valves will be necessary. It will also be necessary to install an absorber unit of approximately 400 cu ft per min and a component balance system will also be installed in the unit.

The California Institute of Technology was purposely selected as the site for the new tunnel as the Institute is a permanent educational center where advanced courses in jet-propelled missiles and their component parts are offered by some of the foremost scientists in the country. Located at this school, the tunnel can be utilized by these scientists not only to instruct other scientific personnel, but also to carry on necessary vital research in the guided-missile field.

Its use will be available to all agencies requiring the services of such a facility.

Sound-Recording System

A HIGH-fidelity sterophonic system for recording sound on film was developed in Germany during the war, according to a report (PB-338) now on sale by the Office of Technical Services, Department of Commerce, Washington, D. C. The system makes it possible to create the illusion of natural auditory depth in the reproduction of sound.

The sterophon system uses three communication channels for reproducing sound as well as for recording it. The recording unit can handle a frequency range of 23 to 10,000 cycles and a dynamic range of 60 decibels with a harmonic distortion of less than 3 per cent. The film noise is 70 decibels below the greatest amplitude. The sound track has a total width of only 2.65 mm and travels at the rate of 45 cm per sec.

The system resembles one of the conventional methods for recording sound on motion-picture film. Sound is converted into electrical signals which by electronic and optical means vary the amount of light falling on a moving strip of sensitized film.

The sound to be recorded enters three condenser microphones which transform it into electrical signals. The signals from each microphone are "processed" in separate electrical channels until they reach a Kerr photoelectric cell.

An amplifier increases their strength and a pair of oppositely connected diodes splits them into positive and negative components or half-waves to help reduce recording noise. An amplifier then steps up the power for the negative half-waves and another does the same for the positive half-waves. Both amplifiers have a band width of 20 kc to eliminate the harmonics introduced by splitting the full waves. Before entering the Kerr cell, the negative and positive half-waves are separately superimposed on a carrier signal of 170 kc to preclude excessive electrolysis in the cell and are then passed through a filter to suppress undesired modulation products.

The Kerr cell obtains two streams of modulated carrier signals from each microphone or communication channel—one stream carrying the negative half-waves and the other the positive half-waves—or a total of six for the three channels. Each stream feeds a separate plate in the cell.

Above and below the cell is a pair of Nicol prisms which polarize light in opposite planes of polarization. Monochromatic light from a high-pressure mercury lamp enters the top prism by way of a focusing lens. When the Kerr cell receives no signals, it remains inactive and plane-polarized light from the top prism moves through it without change. However, on passing into the bottom prism, the light disappears completely, because of the counter polarizing effect.

When signals enter the Kerr cell, they create an electrostatic stress that causes the cell to rotate the plane of polarization of the plane-polarized light coming from the top prism. The angle of rotation depends on the intensity of the signals. As a result, the bottom prism will permit some light to pass through and to be focused on moving photographic film. The amount of light that gets through is determined by the angle of rotation and therefore the intensity of the signals. Since the signals are electrical transcriptions of sounds, the light striking the film produces corresponding, photographic transcriptions.

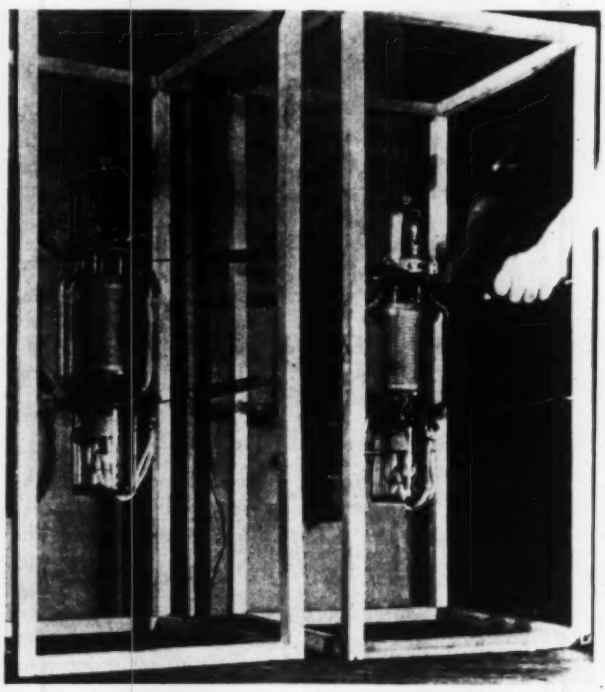


FIG. 11 PACKING ELECTRONIC TUBES

(Final adjustments are made on a spring mounting used for shipping large transmitting tubes by Amperex Electronic Corporation, Brooklyn, N. Y. The units are suspended in rigid wooden frames which fit snugly into corrugated cartons. It is said that this simple shipping method has eliminated much of the breakage formerly experienced with large electronic tubes.)

National Defense

THE National Inventors Council recently released a list of technical problems confronting the Army, Navy, and Coast Guard for consideration by American inventors. Their solution, it was stated, will greatly facilitate the work of the Armed Forces and improve American National Defense.

Some of the typical problems listed follow: Solidification of soils to support emergency operations of aircraft or military vehicles; low-horsepower gas turbines; ultra lightweight gasoline-power units; new types of fuels, lubricants, and additives; development of plastics suitable for use as structural material and special applications; development of lightweight high-strength noncorrosive structural metals; action of materials in low temperatures; draft gages for marine vessels; roll indicators; glider-borne lifeboat; fog detector; miniature radio transmitter; lightweight high-speed Diesel engine; and others.

A full statement of the technical problems may be obtained by writing to the Department of Commerce, The National Inventors Council, Washington, D. C.

The N.I.C. wants to learn of any progress made by private laboratories in solving these problems that is not now known to the Armed Forces. The N.I.C. also wishes to inform American inventors that the Army, Navy, and Coast Guard are as much interested in new and better equipment today as they were during the war years.

All proposals received will be thoroughly studied by the Council and its operating staff. Those recommended will then be forwarded to the proper branch of the Armed Forces for thorough exploration.

Plastic Automobiles

DESIGN from the ground up and development along radical lines of a reinforced plastic automobile were described by Louis A. Werner, engineering consultant of Detroit, Mich., before the summer meeting of the Society of Automotive Engineers held in June, 1947. Mr. Werner said the chassisless vehicle is suspended on air bellows fed from an expansion tank which controls ride softness and maintains constant road clearance.

The body, which carries loads normally absorbed by the chassis, was said to be composed of 10 parts, each separately molded from plastic reinforced by glass cloth, and then joined. The floor was reported to be made of honeycomb-type cells, the windshield curved and affording unusual visibility at all times and in all weathers. The rear-mounted engine was said to form a unit with axle and transmission, while a new two-wire electrical system operates all controls and instruments, even door locks.

Developments in Fuels, Lubricants and Lubrication

(Continued from page 576)

some of the additives used, while keeping the engine cleaner, have shown some tendency to combine with lead products from the fuel and increase combustion-chamber deposits and foul plugs.

Foaming of lubricating oils is not materially different for any normal oil, but in general the additives, especially the detergent group, increase foaming. A valuable antifoam agent was discovered by the author's laboratory, and is now rather generally used. It is employed in very small concentration, 0.01 per cent or less, and completely suppresses foam at a free surface. It is certainly not a panacea, as it can do little about entrained air bubbles, submerged in oil. The cause of foaming is improper design, and it is much better to prevent the formation of foam than to break it after it is formed. Many combat-vehicle cases, particularly gearboxes and lube-oil tanks, with no opportunity to improve the design, were taken off the sick list by this antifoam agent.

Gear oils have not changed much, but the lighter 75 gear oil developed for Army Arctic service worked out well. Before the war, the use of much lighter gear oils (S.A.E. 10 and 20) was investigated; present results indicate that it may be possible to substitute these light oils for the heavier material, possibly with the use of additives of an E.P. nature, similar to hypoid lubricants. The reward is noticeable in high-speed gears, where lubricant pumping losses and heat developed may be excessively high with viscous oil.

There has been, especially during the last 2 or 3 years, increased attention to the development of cutting and grinding oils. Cutting-oil problems have been with us for a good many years, and the principles on which cutting oils operate have never been very clearly defined; the job is far from done yet. The same is true of the newer grinding oils now used to produce fine finish at high production rates without burning the finished parts.

The materials added to mineral oils for the purpose of providing the proper cutting and grinding properties and likewise to replace the more perishable animal oils, such as lard oil, now consist chiefly of chlorine and sulphur compounds. The major improvements consist of introducing these compounds in such forms as will give the best over-all result: There is only one way of determining this result, and that is by actual cutting or grinding tests. Consequently, this work is quite expensive inasmuch as it requires the installation, in many cases, of commercial thread-grinding equipment for grinding oils; in the case of cutting oils usually machine tools will be available but must be largely removed from normal production for such tests.

The improvements, as pointed out, consist of the choice of chemical combinations that give the best result using chlorine and sulphur, and after that, removal of odor, which is very often quite pronounced. At the present time it appears that the properties most needed in cutting oils are oiliness and some kind of E.P. effect similar to that developed originally for use in hypoid gears.

CONCLUSION

Summing up, the war-forced developments have been good but not startling. No miraculous changes have taken place or are expected, but the advance of quality and performance has been accelerated. Probably the major development, other than atomic fission, is that of the commercial production of the gas turbine. It is interesting to reflect on the possibility that if the gas turbine largely replaces the reciprocating engine, the need for high-octane gasoline would disappear. The gas turbine does not pose any new lubricating problems, only extends two factors, temperature and speed. All other conditions should be easier than reciprocating internal-combustion engines, because the lubrication is not carried on in the presence of combustion and combustion products.

The designers of gas turbines are urged to consider designing for normal fuel oils, and to remember in packing their "hell-fire pinwheel" in small space, that all organic liquids break down by 650 F. Therefore the lubrication system should not be treated as a hit-or-miss auxiliary service, as it was in the reciprocating engine.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

60 Years With Men and Machines

60 YEARS WITH MEN AND MACHINES. An Autobiography. By Fred H. Colvin, in collaboration with D. J. Duffin. Whittlesey House, McGraw-Hill Book Co., Inc., New York, N. Y., 1947. Cloth, 6 × 9 in., 297 pp., illus., $3.50.

REVIEWED BY J. W. ROE[1]

THIS book is the result of much prodding by Fred Colvin's friends. Few men have had 60 years of experience with machine tools and toolbuilders. Fewer still have Colvin's memory, humor, and ready pen to write about it. That pen, or perhaps typewriter, has been busy. He has written more than forty books, representing nearly seven million words, with sales totaling over a million copies, and countless articles and editorials in *Machinery*, *Locomotive Engineering*, and the *American Machinist*. Probably no other technical writer has reached so many workmen, designers, and engineers here and abroad.

Machinery was in his blood. His grandfather was a gunsmith and his father a locomotive engineer. Colvin himself began as an apprentice in the Rue Manufacturing Company in Philadelphia in 1883 at three dollars a week. This shop made injectors, employed twenty-five to thirty workmen, and had thirty-four machine tools, all belt-driven by a 25 hp Corliss engine. Everyone knew everyone else, dug chips out of each others' eyes, and untangled the bunglers who got caught in the belting. He worked there for nearly ten years, and then, lured by fifteen dollars a week, for the Wheelock Engine Company, in Worcester, Mass., for two years.

Colvin's first article appeared in the *American Machinist* in 1886. The increasing flow of excellent letters and articles on tools and shop practice led to his appointment in 1894 as the first editor of *Machinery*, then just starting. He has been an editor and writer ever since. For thirty years he was an editor of the *American Machinist* and for the past ten years, editor-emeritus. These last years have been busier than ever. In fact some of his best work has been done during this last World War.

Probably no man living has a wider knowledge of or longer experience with machine tools and their application. This book is a record of that experience, beginning in a small shop in the belt-drive era, and covering the development of the early technical journals, the founding of the A.S.M.E., and the growth of the bicycle, automobile, and aircraft industries. He tells of the tooling and production problems of the Army and Navy in the first and second World Wars.

There are two books which remind the reader of this one. The first is the "Extracts from Chordal's Letters," which appeared in the early years of the *American Machinist* and were later published in book form. These give a salty, vivid picture of life in the small shop of the 1880's and are full of keen observations and sound sense. Colvin's early chapter on the belt-drive era gives a similar picture.

The other book is the autobiography of James Nasmyth who invented the shaper and the steam hammer. It is the record of another long life which begins in the shop of Henry Maudslay in London, England, where modern machine tools began, and comes down to the middle of the last century. It is as English as Colvin's book is American and, like it, is delightful. Colvin's book has the merit of both these. It gives a picture of the horse-and-buggy days of Chordal's time, and a record of the growth and development of the metal-working industry in America, as Nasmyth does for England.

"60 Years with Men and Machines," however, does leave one thing to be desired. Colvin has a genius for friendship as well as for machines, and while he has told us much about tools he could have told more than he has about the toolbuilders. Many of them were interesting men who contributed much and are little-known. Colvin knows them as few do and can still tell about them. We hope that he will.

Some grow old gracefully. Fred Colvin does not seem to grow old at all. Those who have sat in with him on committees and in conferences during the past war have often found him, at seventy-five plus, the most alert and forward-looking person there. Today he is an active consultant on the atomic-power project, the latest and most challenging problem we have.

The book closes with this paragraph. "It is a far cry from the old shop at 211 Race Street in Philadelphia to the vast atomic energy plant at Oak Ridge, and I have greatly enjoyed writing down the experiences and the observations of that hectic interval of industrial progress. I hope the reader has enjoyed it as much as I have."

We have enjoyed it, and we hope many others may.

[1] Southport, Conn. Fellow A.S.M.E.

War Department Research

WAR DEPARTMENT RESEARCH AND DEVELOPMENT PROGRAM, FISCAL YEAR 1948. Prepared under the supervision of the Plans and Policy Office, Research and Development Division, War Department General Staff, Washington, D. C., January, 1947. Photo-offset, paper covers, 8 × 10½ in., 79 pp.

THERE has been made available recently a compilation of the individual programs of the research and development agencies of the War Department for the fiscal year of 1948. In keeping with current policy, the over-all program has been prepared well prior to the fiscal year in which it will be in effect. Confidential material has necessarily been omitted, but every effort has been made to give as true a picture of the program as is consistent with national security.

The research plan has been divided into two separate programs, one for the Army (Technical Services), and one for Air (Engineering Division, Air Matériel Command). Co-ordination of the over-all program is achieved by assigning primary and collateral cognizance to the several developing agencies wherever possible.

There are several policies which are of general interest to the scientific and engineering fraternity as a whole. First, the U. S. Army's research agencies will utilize civilian educational institution and industrial laboratories to the maximum possible extent. Second, the results of

pure research generally will be maintained in a nonconfidential status to allow for freedom of discussion, while security classifications generally will be continuously reviewed on all existing projects with the view to declassifying so as to permit early dissemination of information. Third, a minimum of expense and effort will be employed to improve existing conventional weapons. Finally, full advantage will be taken of modern statistical and mathematical techniques in the design of experiments, and in the conduct of engineering and service test analysis.

Stress is placed on new weapons, equipment, and materials, the application of lightweight materials wherever possible, and new techniques. All development will be constantly governed by the potential effects of atmospheric environments and the limitations imposed by the human system which must use the equipment and exist in the environments simultaneously.

Items of more specific interest to A.S.M.E. members are noted as follows:

Petroleum Products. Work will be directed toward an increase in efficiency of petroleum-distribution systems. Gas and steam-turbine prime movers will be investigated for use on high-specific-speed centrifugal pumps. Airfield-refueling systems will be investigated because of greatly increased fuel requirements of new aircraft. The chemical and physical nature of fuels and lubricants will be studied to develop the relation of the properties to the phenomena of lubrication, combustion, and rust protection. A number of new synthetics now becoming available will be under investigation for possible applications as fire-control instrument lubricants, and as recoil and hydraulic oils.

Railroads. Modification of the lightweight Diesel electric locomotive under development is planned for application to tracks of various gages. Development will be made of a basic hospital car for a number of uses depending on interior arrangements, and for use on tracks of various gages.

Marine. For special vessels designed to have access to extremely shallow water, or to marsh and debris-laden water, consideration will be given to propulsion by hydraulic jet, low- and high-pressure gas jet turbine, turbojet, and air screw, rather than by a conventional water screw.

Ballistics and Armor. Bases for ballistic design for all types of missiles must be established for speeds which have been nonattainable in the past. Attention will be given to the development of lightweight high-strength aluminum alloys suitable for armor in place of steel on many ordinance items, together with the welding thereof to produce joints of high efficiency.

Electronics. Radar, loran, television, sound equipment, and the detection of friendly and enemy guided missiles, as well as electronic countermeasures, will receive considerable concentration of effort.

Materials Handling. Under an integrated transportation-system program, a complete study of the present systems and future requirements will be conducted to determine bottlenecks and to devise means of correction. The program to improve packaging methods includes such elements as (*a*) establishment of uniform size where practicable; (*b*) standardization of sizes to fit an optimum number of containers, pallets, vehicular bodies, railroad cars, and ship holds; (*c*) material-handling equipment must be devised or modified in order to meet unusual conditions of load transfer and to simplify routine handling.

Air Matériel Command. Development will be under way on lightweight flame-resistant hose for aircraft fuel, oil, coolant, and hydraulic systems; on rubber-compounding ingredients and new plasticizers; on substitutes for cadmium and zinc in plating processes; on the use of lead and indium deposition for bearings; on the effect of low temperature on strength properties of extruded aluminum alloys; on laminated plastic materials, and on ceramic coatings.

For aircraft power plants, future research and development is required in the field of gas-turbine engines to provide engines of higher output with greater internal efficiency and with improved components of construction. There exist problems of (*a*) combustion (flame speeds, chemical reactions during gas combustions, acoustical oscillations in the burners, etc.); (*b*) materials of construction (the major problem relates to the search for high temperature-resisting metals or ceramic-metal bodies); (*c*) design (methods of attaching blades to the turbine disk, design and construction of large turbine disks, the problem of main bearing operation at 10,000 to 20,000 rpm, and the improvement of the efficiency of components such as the compressor and turbine).—R. A. O'B.

Personality and English

PERSONALITY AND ENGLISH IN TECHNICAL PERSONNEL, by Philip McDonald, D. Van Nostrand Company, Inc., New York, N. Y. 1946. Cloth 5⅝ × 8¼, 424 pp., $3.75.

YOUNG men and women training for or working in the field of science and engineering will find in Philip McDonald's discursive book, "Personality and English in Technical Personnel," two valuable bits of advice to guide them in their pursuit of a career. Professor McDonald, who teaches English in the College of Engineering at New York University, admonishes young people to cultivate a command of spoken and written English and to develop a historic sense by extensive readings in ancient and modern history.

Professor McDonald is concerned over the defects in personality which he says are the common by-products of overspecialization in science and engineering. Among these he lists inability to write and speak effectively, lack of a sense of proportion when faced with nontechnical problems, and lack of the historical point of view. In contrast to the technical specialist, he points out that the "managerial type" of man, even though of mediocre ability, may achieve surprising success if he has been exposed to humanistic studies.

Too often, the scientist or engineer, when he is away from his special tasks, tends to "accept as true, many misleading statistics, superficial assertations, and misinterpreted arguments, especially those pertaining to social and economic subjects—even when the deception is fairly obvious."

So absorbed is he in the details of his specialty that he neglects the cultivation of social amenities which are the hallmarks of a cultured man. Because he seems to neglect small points of conduct, appearance, and speech, he often makes an unfavorable impression on his prospective employer or loses the confidence of his boss. When opportunity whispers, he does not hear, and when it shouts, he fumbles. Unaware of the history of western culture, he remains unmoved by situations which arouse in others a wealth of historical precedent upon which to base decisions and form opinions.

Professor McDonald's "useful suggestion" for self-improvement in English is a 200-page digression into the principals of English composition. While his comments are valuable when he discusses the faults of technical papers presented at engineering-society meetings, he contributes little which has not been adequately covered in many books on composition.

His digression into the history of western culture extends through 150

pages which review the substance of ancient philosophy and the sources of modern science. Although Professor McDonald treats material which should be of great interest to engineers, his reliance on hindsight wisdom, his apparent impatience with the slow development of science, and his lack of understanding of the difficulty of original scientific thinking, may irritate older readers.

So far afield does the book digress from its original theme that the 424 pages in which the author takes to cover his points, is in reality, three different books which discuss in turn defects in personality of technical personnel, English composition, and the history of western thought and science.

The ambiguity of the title is reflected throughout the book. Chapter headings often hold the key to the first paragraph, but give no indication of the ideas which follow. The same points are covered time and time again. As a whole, and in its individual chapters, the book lacks unity and a logical sequence of ideas which a technically trained man demands. Its length and style may exhaust the patience of some readers.—A. F. B.

Accident Prevention Administration

Accident Prevention Administration. By Frederick G. Lippert. McGraw-Hill Book Co., Inc., New York, N. Y., 1947. Cloth, 6 × 9 in., 159 pp., $2.25.

REVIEWED BY E. R. GRANNISS[2]

THE science of accident prevention has advanced rapidly during the last few years. During the war, accidental interruption of production was a serious matter and safety programs were fostered by the Army and Navy Departments in all plants manufacturing vital materials. Such incentive to organized safety work brought forth a wealth of pertinent literature, some good and some, hurriedly composed, not quite so good.

The postwar period also is producing much written material and one of the newer and better books is "Accident Prevention Administration" by Frederick G. Lippert.

Lippert reviews much of the standard and orthodox material already in print and does it clearly and concisely. His treatment of basic causes and costs of accidents, collections and analysis of data, inspection and methods of correction, follows established practices.

By introducing a chapter on Union Participation, however, he takes a relatively new and courageous step. This is a subject that safety writers have tended to avoid. In this chapter, Lippert is undoubtedly writing from personal experience and the information should be of more than ordinary value to industrial safety directors and supervisors.

A safety training course for workers is not new, but it is well organized and should prove useful. His chapters on policy and procedure and the operation of an over-all safety program should also be of value.

This book deserves space in the libraries of all safety engineers and industrial supervisors. It takes its place beside the more intelligently prepared and the useful, practical, accident-prevention texts of recent years.

[2] Manager, Engineering Department, Eagle-Globe-Royal Indemnity Companies, New York, N. Y. Mem. A.S.M.E.

The Problem of Reducing Vulnerability to Atomic Bombs

The Problem of Reducing Vulnerability to Atomic Bombs. By Ansley J. Coale under the direction of the Committee on Social and Economic Aspects of Atomic Energy of the Social Science Research Council. Princeton University Press, Princeton, N. J., 1947. Cloth, 5 1/4 × 7 3/4 in., 116 pp., $2.

REVIEWED BY W. I. WESTERVELT[3]

THIS is a valuable and timely book; a stimulus to needed responses; an urge to contemplation of the vital and pressing problems having to do with threats implicit in the hostile employment against the U. S. of the forces released by atomic bombs.

The author and the sponsors as well have performed a useful service in sounding fundamentals; from now on it is hoped and anticipated that accelerated progress will be made in doing whatever is necessary from the engineering point of view.

In whatever fashions the reduction of vulnerability to atomic bombs could and would be accomplished, such achievements would still be an end product of a defense formulary. The author, while giving his deepest consideration to the ideas and phenomena of reducing vulnerability, appears to me to be fully aware of the importance of offense as a controlling concomitant of defense.

By all means let us play safe or as safe as we can; we must never relax in our efforts to create better tools of offensive warfare.

[3] Member, Nuclear Energy Application Committee, A.S.M.E.

Books Received in Library

A.S.T.M. STANDARDS including Tentatives, 1946. 5 vols: Part I-A, Ferrous Metals, 1181 pp.; Part I-B, Non-Ferrous Metals, 917 pp.; Part II, Nonmetallic Materials—Constructional, 1762 pp.; Part III-A, Nonmetallic Materials—Coal and Coke, Petroleum Products, Aromatic Hydrocarbons, Soaps, Waters, Textiles, Gaseous Fuels, 1290 pp.; Part III-B, Nonmetallic Materials—Electrical Insulating Materials, Plastics, Rubber, Paper, Shipping Containers, Adhesives, 1360 pp. American Society for Testing Materials, Philadelphia, Pa., 1947. Cloth 6 × 9 1/4 in., illus., diagrams, charts, tables; Parts I-A, I-B, III-A, or III B, $8 each; Part II, $12; complete set of all five parts, $44. Now covering more than 1400 specifications, tests, etc., this new combined edition contains all of the standards, adopted and tentative, as of the present date. In order to accommodate the increased number of items the present edition is in five volumes instead of three, as follows: the metals volume is split in two parts, ferrous and nonferrous; the nonmetallic constructional materials remain in one volume; the other nonmetallic materials are in two volumes, one covering fuels, petroleum products, and textiles; and the other covering plastics, rubber, paper, adhesives, and electrical insulation. These volumes may be bought separately.

CENTURY OF SILVER 1847–1947, Connecticut Yankees and a Noble Metal. By E. C. May. Robert M. McBride & Company, New York, N. Y., 1947. Cloth, 5 1/2 × 8 1/4 in., 388 pp., illus., $3.50. Essentially the history of the activities of the International Silver Company from the days of the Rogers Brothers in the early 19th century up to the present, the pattern of American industry is represented in the problems met and the solutions achieved. Along with the accounts of personalities, activities, and incidents, the book traces the evolution of silverware in mass production from early plated ware made at home by crude processes to the plated and sterling ware produced by modern methods.

CLIMATE AND THE ENERGY OF NATIONS. By S. F. Markham. Oxford University Press, New York, N. Y., 1947. Cloth, 5 1/2 × 8 1/2 in., 240 pp., illus., diagrams, maps, tables, $4.50. This book presents a scientific study of civilization from its early period to the present day, based on an acceptance of the general thesis that climate conditions energy. As tests of national energy, the author examines the death rate, infant mortality, national incomes, and world trade. The use and value of artificial climatic control (heating, air conditioning, etc.) are discussed. Some predictions and suggestions for the future are given in the final chapter. A considerable part of the factual information is presented in the form of tables, graphs, and maps for easier understanding.

CONSTRUCTION DES AVIONS. By G. du Merle, preface by P. Dumanois. Second edition. Dunod, Paris, France, 1947. Paper, 7 1/2 × 11 in., 855 pp., illus., diagrams, charts, tables, 2350 frs. Intended mainly for the aeronautical engineer, this comprehensive treatise contains a wealth of useful information for any one interested in aviation. Both the external and internal structure of the conventional plane are described, aerodynamic characteristics are discussed, and equipment for suspension, fuel supply, lubrication, cooling, and controls of various kinds are dealt with in detail. Considerable space is devoted to important manufacturing procedures. There are chapters on safety and comfort in flight, special types of planes (helicopters, jet planes, gliders, etc.), civil and military operation. Photographs, three-projection views, and tables of characteristics are included for all important French and foreign airplanes. There are a glossary and two detailed indexes, by subject and by type of plane.

CONTROLLED ATMOSPHERES FOR THE HEAT TREATMENT OF METALS. By I. Jenkins, with a foreword by C. J. Smithells. Chapman & Hall, London, England, 1946. Cloth, 5 1/2 × 8 3/4 in., 532 pp., illus., diagrams, charts, tables, 50s. The main function of a controlled atmosphere in the heat-treatment of a metal is considered to be the control of the surface chemistry, as distinct from the metallurgy, of the process. This involves the application of certain laws of physical chemistry to various gas-metal and intergas reactions. This book brings together the scattered data on these reactions, discusses fundamental principles, and explains the means of translating these principles into practice. The book is arranged in three sections covering respectively the generation, purification, and application of controlled atmospheres, including details of industrial equipment.

DICTIONARY OF PLASTICS. Compiled by P. I. Smith. Hutchinson's Scientific & Technical Publications, London, England, New York, N. Y., Melbourne and Sydney, Australia, and Cape Town, S. Africa. 1946. Cloth, 5 1/2 × 8 3/4 in., 168 pp., diagrams, tables, 15s. This dictionary is intended to supply in concise and accurate form descriptive information and numerical data for the materials, processes, products, and applications of the plastics industry. Considerable selectivity has been exercised on the matter of inclusion, owing to the large number of possible chemicals and compounds which may be utilized, and because of the desire to keep the book to a convenient size. References selected for insertion are those mainly concerned with products rather than manufactured goods, and no attempt has been made to provide a complete list of trade names. There is a bibliography.

FALK'S GRAPHICAL SOLUTIONS to 100,000 PRACTICAL PROBLEMS, prepared and edited by K. H. Falk. Columbia Graphs, Columbia, Conn., 1946. Cloth, 6 × 9 1/2 in., 402 pp., charts, $6. This volume contains 400 worked-out graphs covering standard calculations for a large variety of practical problems in mechanics, hydraulics, electricity, physics, chemistry, shopwork, construction, trigonometry, weights and measures. The graphs are all of the simple type in which the intersection of two lines, established by the known quantities, provides the direct answer.

GENERATORS AND MOTORS and Their Applications. By D. J. Duffin. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1947. Cloth, 7 1/4 × 10 in., 210 pp., illus., diagrams, charts, tables, $4. This manual, for on-the-job use by armature winders and electric-motor repairmen, presents fundamental motor and generator theory. It provides important working data on a wide variety of types and makes of alternating-current and direct-current equipment. Clear-cut external, sectional, and disassembled views of machinery add to its practical value. This first of a projected series of three manuals also contains information on selection, applications, maintenance, and trouble shooting.

Guide to the LITERATURE OF MATHEMATICS and PHYSICS including Related Works on Engineering Science. By N. G. Parke, 3rd. McGraw-Hill Book Company Inc., New York, N. Y., and London, England, 1947. Cloth 6 × 9 1/4 in., 205 pp., tables, $6. A detailed bibliography is presented of world literature in the field of mathematics and physics, and related aspects of engineering science. Containing about 1800 entries, the book provides scientists and research engineers with a valuable key to authoritative information, with strong industrial emphasis, on a wide range of subjects from algebra to atomic and nuclear physics. The main arrangement is an alphabetical subject classification, with orienting paragraphs and an author index. The early part of the book contains a helpful section on reading, reference, and library techniques

Matthews' TEXTILE FIBERS, Their Physical, Microscopical, and Chemical Properties. Fifth edition, prepared by a Staff of Specialists under the Editorship of H. R. Mauersberger. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1947. Cloth, 6 × 9 1/4 in., 1133 pp., illus., diagrams, charts, tables, $12.50. Prepared by a staff of specialists, this comprehensive treatise covers all natural fibers, regenerated fibers, and synthetic fibers. Each type of fiber is dealt with separately, and the physical, microscopical, and chemical properties of each are cited. Among physical properties are considered the mechanical, thermal, optical, and electrical characteristics which affect the utility of the fiber. Microscopical testing, identification, and quantitative and qualitative analysis of textile fibers and yarns are discussed in the light of recent developments. The reactions of each fiber to organic and inorganic chemicals used in cleaning, mercerizing, bleaching, dyeing, etc., are presented in detail as important considerations in the processing of textile materials. A detailed subject index and chapter bibliographies are included.

MODERN PLASTICS ENCYCLOPEDIA 1947, 3 Vols. Plastics Catalogue Corporation, 122 East 42nd St., New York 17, N. Y. Fabrikoid, 8 3/4 × 12 in., illus., diagrams, charts, tables, 3 vols., U. S. A., $8.50; Canada, $11; foreign, $12. Vols. 1 & 2, 1556 pp. Vol. 3 consists of 10 charts, price of volume separately, $3.75. The three volumes of the new edition of this comprehensive work are arranged as follows: Vol. 1 covers the recent developments and applications of all types of materials, coatings, films, fibers, fabrics, laminates, and resin-woods, together with a comprehensive new section on optical properties of plastics; Vol. 2 is devoted to processing problems, dealing with engineering design, construction design, molding, extruding, casting, fabricating, finishing, and assembly. Latest developments in machinery are described, plant layouts are suggested, and complete directories of the plastics industry are included; Vol. 3 is devoted entirely to ten special charts listing properties, etc., of a wide variety of plastics materials, classified by nature or function. Among other new features is a bibliography of reports on German plastics.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

Society for EXPERIMENTAL STRESS ANALYSIS, Proceedings vol. 4, no. 1, edited by C. Lipson and W. M. Murray; published and distributed by Addison-Wesley Press, Inc., Kendall Square, Cambridge 42, Mass., 1946. Cloth, 8 1/4 × 11 1/4, 129 pp., illus., diagrams, charts, tables, $6. The current volume of this semi-annual publication contains twelve papers by specialists. Topics covered include strain rosette analyses and computations, stress studies of various mechanical structures, brittle lacquer indications of residual stresses, impact on prismatical bars, and the pressure of plastic concrete in forms. A list of members of the Society is included.

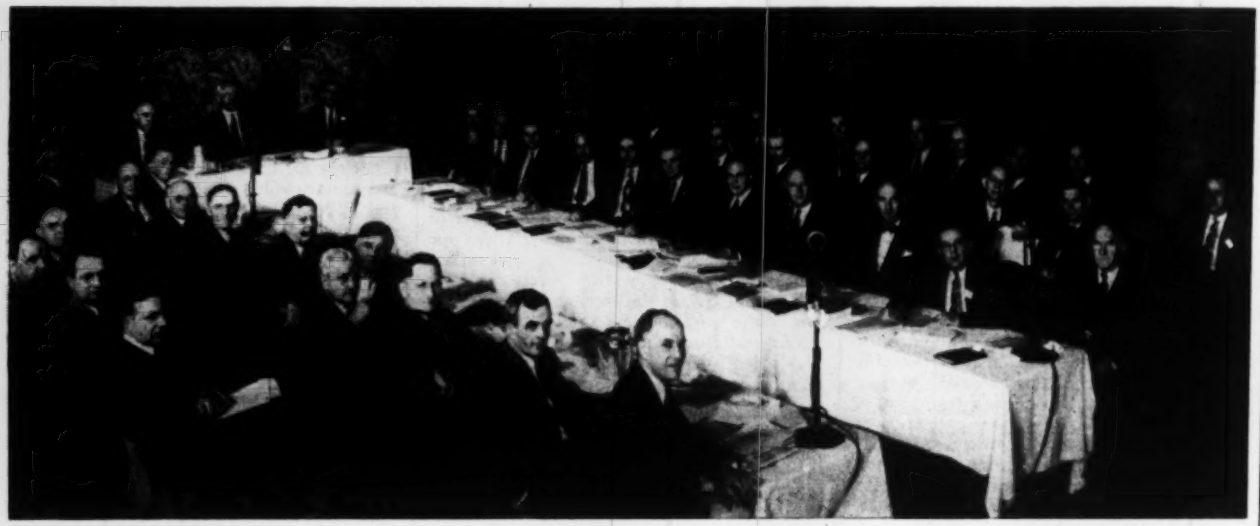
TABLES OF INTEGRALS and Other MATHEMATICAL DATA. By H. B. Dwight. Revised edition. The Macmillan Company, New York, N. Y., 1947. Cloth, 5 1/4 × 8 1/2 in., 250 pp., diagrams, charts, tables, $2.50. Classified groups of derivatives and integrals are given for algebraic, trigonometric, exponential, logarithmic, hyperbolic, elliptic, and Bessel functions. Inverse trigonometric and hyperbolic functions are also covered, as are probability integrals, surface zonal harmonics, definite integrals, and differential equations. Tables of numerical values for various functions, logarithms, constants, etc., are appended, and there is a list of references.

UNIFIED CALCULUS. By E. S. Smith, M. Salkover, and H. K. Justice. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1947. Cloth, 5 1/2 × 8 1/2 in., 507 pp., diagrams, charts, tables, $3.50. Planned as a first course in calculus, this text presents the fundamental ideas and applications of both differential and integral calculus in an alternating manner to demonstrate the unity of the subject. The correlation of calculus with physics and mechanics is emphasized by the early inclusion of problems dealing with important basic concepts in these fields. Differentials are given special consideration as the connecting link between differentiation and integration, and there is a chapter on differential equations.

WELDING SYMBOLS. By V. C. Gourley. Bruce Publishing Company, Milwaukee, Wis., 1947. Cloth 5 1/2 × 8 3/4 in., 115 pp., illus., diagrams, tables, $2.50. The general standards for the use of arc-, gas-, and resistance-welding symbols are explained in a simple, graphic way. Illustrations consist of two parts: the drawing specifies the weld in the same manner as an actual mechanical drawing or blueprint; the explanation interprets the drawing, showing pictorially the exact location and outline of the weld. The standards and symbols demonstrated are the ones recognized by the American Welding Society. An illustrated glossary is included.

A.S.M.E. NEWS

And Notes on Other Engineering Societies



THE A.S.M.E. BOILER CODE COMMITTEE AT ITS MEETING IN LOS ANGELES, CALIF., MAY 9, 1947

(Members of the Committee are: *Foreground at the table right to left and around:* D. B. Rossheim, A. L. Penniman, Jr., H. C. Boardman, P. R. Cassidy, C. O. Myers, A. J. Ely, C. W. Obert, R. E. Cecil, C. A. Adams, F. W. Davis, H. E. Aldrich, vice-chairman, H. B. Oatley, chairman, J. W. Shields, James Partington, D. B. Wesstrom, alternate for S. K. Varnes, W. D. Halsey, Walter Samans, R. Milligan, alternate for D. L. Royer, J. W. Turner, F. S. G. Williams, J.Kruse, alternate for A. C. Weigel, W. P. Gerhart, and E. R. Fish, honorary member. Members of the Committee not represented are: D. S. Jacobus, honorary chairman, V. M. Frost, and W. F. Hess. Those unnamed attended the meeting as observers.)

A.S.M.E. Boiler Code Committee Hearings Discuss Revisions to Code for Unfired Pressure Vessels

Committee Visits Student Branches

ENGINEERS of the unfired-pressure-vessel industry in a candid exchange of views at the public hearings of the A.S.M.E. Boiler Code Committee vigorously discussed the proposed revision of Section VIII of the A.S.M.E. Boiler Construction Code for unfired pressure vessels and displayed a spirit of compromise which augers general acceptance of the proposed revision by the industry. The question of dual inspection was of much interest to representatives of the petroleum industry. Users, manufacturers, and state and municipal inspectors agreed unofficially to organize a small group to resolve points of difference brought out by the discussions.

The public hearings were held at the Rice Hotel, Houston, Texas, May 1 and 2, 1947, and in the Biltmore Hotel, Los Angeles, Calif., May 7, 1947, at which 200 representatives of the unfired-pressure-vessel industry and those concerned with public safety discussed the features of the proposed revision of Section VIII, copies of which had recently been made available by the A.S.M.E. for public comment.

Revision of Section VIII was initiated by the A.S.M.E. not only to rearrange existing sections of the Code which have grown considerably throughout the years, but also to enlarge it to cover nonferrous constructions. It was believed that proper revision might eliminate the need of other existing codes in the unfired-pressure-vessel field.

Two Codes Discussed

Because of the particular requirements and the extensive use of unfired pressure vessels in the petroleum industry, the A.S.M.E. and the American Petroleum Institute in 1934 published the A.P.I.-A.S.M.E. Code for Unfired Pressure Vessels for Petroleum Liquids and Gases. The inspection requirements in this code, however, differ from those in Section VIII of the A.S.M.E. Boiler Construction Code in that Section VIII requires inspection by a state, city, or insurance-company inspector, while the A.P.I.-A.S.M.E. Code requires inspection by an agent of the purchaser or an independent inspection agency.

It was brought out that the necessity for dual inspection arises for a manufacturer who wishes to ship a vessel inspected by the purchaser's inspector into a state where the A.S.M.E. Code has been adopted and which requires inspection by a state, city, or insurance-company inspector. A similar situation arises in the petroleum industry where company inspectors are extensively employed but where authorized inspectors are not often in residence. Expensive delays after breakdown and repairs result because operations must be held in abeyance pending arrival of an authorized inspector.

The discussions at the hearing, although covering many details of construction, centered on two main points: The advantage accruing from a single code covering unfired pressure vessels; and the actual value of or need for third-party inspections. On the first point, there was a general feeling of agreement that two codes are unnecessary and that the proposed revision of the A.S.M.E. Code for Unfired Pressure Vessels might eliminate conflicts and save industry time and money. On the second point, there was a division of opinion between the users and manufacturers and the representatives of the inspection services.

Representatives of the petroleum industry

felt that dual inspection was a troublesome and time-consuming burden on the industry, and said that they would like to see company inspectors commissioned by the National Board of Boiler and Pressure Vessel Inspectors because company inspectors, by nature of their work, acquire experience and familiarity with a special product which puts them in a position to expedite inspection operations.

It was pointed out that existing laws of some states are not too comprehensive with respect to pressure vessels, and for this reason the petroleum industry and insurance companies have carried the burden of responsibility for public safety. While such practice is legal in one state, there can be no assurance that such a vessel may not be shipped to another state where the A.S.M.E. Boiler Code is in force. When such a vessel is rejected upon reinspection, the manufacturer and purchaser are subjected to losses. On the other hand, views regarding the advisability of disinterested third-party inspection were expressed by others closely associated with the general problem. The discussions probed into both sides of the question but while the opinions expressed were divergent, there was a general feeling that they were being given in a spirit of conciliation engendered by the belief that compromise was necessary for the general good.

Frank Discussions Cause Satisfaction

Opinions were expressed candidly. There was satisfaction too, that all phases of the problem were discussed frankly before an audience of all shades of opinion who were directly affected by the existence of the two codes. The hearings reflected progress and promised some kind of compromise. Although no specific action was expected on the inspection question, there was an understanding between the two groups that a small committee should shortly be appointed to work on a resolution of the points of difference.

Interested observers at the hearings were state and municipal inspectors of the United States and several officials of Canadian inspection agencies, all of whom were members of the National Board.

In addition to the general assembly of the hearing, the Committee held three panel sessions covering such subjects as power boilers, headed by H. E. Aldrich and members of the Subcommittee on Power Boilers; pressure-vessel design, headed by F. S. G. Williams, Walter Samans, and D. B. Rossheim of the A.S.M.E. Boiler Code Committee; and valves, headed by W. P. Kliment of the Committee. Approximately 100 guests attended the panel discussions and much interest was shown in bringing the eastern and western ideas together.

More than 50 members and associates of the A.S.M.E. Boiler Code Committee left New York, N. Y., on April 29, 1947, to participate in the hearings. At Houston, Texas, they were joined by 100 engineers from the South and Southwest, and some of these continued on to Los Angeles, Calif., where the second hearing was held and where the National Board of Boiler and Pressure Vessel Inspectors were holding their 1947 General Meeting.

Local arrangements at Houston were made by the A.S.M.E. South Texas Section. While members were engaged in the hearings, wives of members enjoyed a sight-seeing tour sponsored by the women of the Section.

Committee Meets With Student Branches

On May 2, several members of the Boiler Code Committee took time out to meet with the A.S.M.E. Student Branch of Rice Institute. Here six members of the Committee spoke on the history, responsibilities, and procedures of the Committee, and gave the student members a firsthand picture of how the A.S.M.E. functions to serve industry.

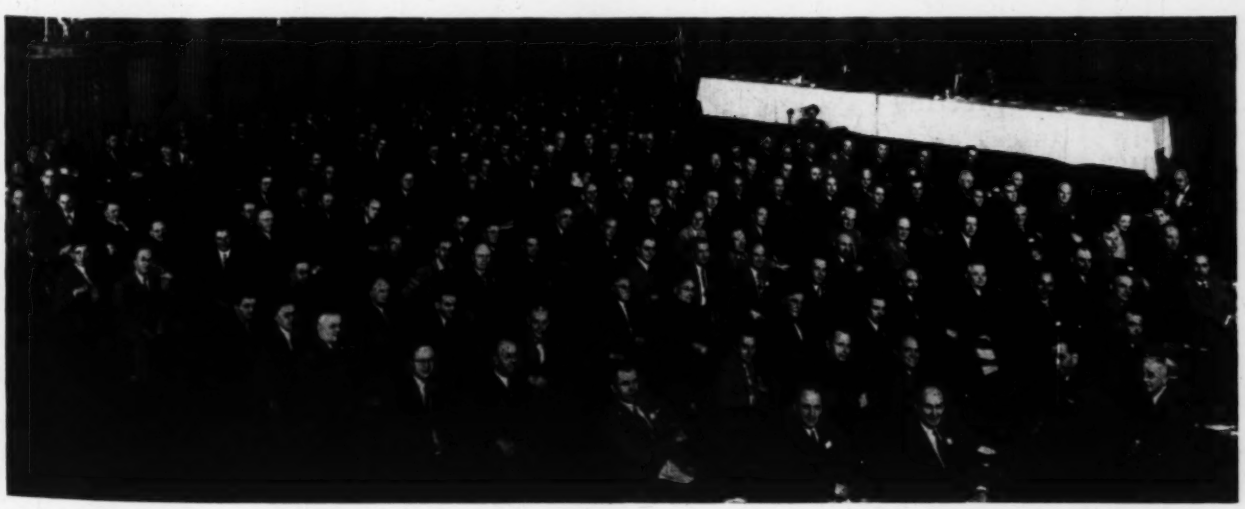
In Los Angeles, Calif., the Committee met with the A.S.M.E. Student Branch of the University of Southern California. Dr. C. A. Adams gave a talk on the engineering approach to industrial problems. W. D. Halsey gave the young men a comprehensive picture of the history of boilers. H. C. Boardman, P. R. Cassidy, and E. O. Bergman completed the program with a talk on engineering materials and design from the point of view of public safety. The student response was very favorable and much interest was given the visitors. The visiting Committee members were shown about the campus and were guests at a luncheon in the college cafeteria.

Attended National Board Meeting

The Committee participated actively in the program of the National Board general meeting. At the close of the first business day, Monday, May 5, the A.S.M.E. Southern California Section tendered a reception and cocktail party to the Boiler Code Committee, the National Board members, wives and guests, enabling all the opportunity for relaxation and fellowship.

Trips for the visiting women were arranged by a local committee headed by J. Calvin Brown, vice-president, A.S.M.E. Region VII, to the Hollywood Studios, Catalina Island, and a tour of the city of Los Angeles which all agreed to be as beautiful as expected. The Boiler Code Committee and National Board members also visited the plants of four local pressure-vessel manufacturers, The Clayton Manufacturing Company, the Steammaster Boiler Works, Mund Boiler Works, and the C. F. Braun Company. One of the interesting visits was to the C. F. Braun Company, where facilities for manufacture of petroleum equipment and unfired pressure vessels were inspected. Here each designer was found to have an individual office fitted with latest drafting aids and engineering references. The main building of the company contains more than 50 such offices. Plant layout, material handling, process control, cleanliness, and automatic equipment were noted with much praise from the Committee visitors. After the inspection tour, a supper was served at which C. F. Braun welcomed the guests and called upon old friends in the group to say a few words.

A high light of the social event was a banquet and dance held in the grand ballroom



AT THE A.S.M.E. PUBLIC HEARING ON PROPOSED REVISION OF SECTION VIII CODE FOR UNFIRED PRESSURE VESSELS HELD BY THE A.S.M.E. BOILER CODE COMMITTEE AT THE BILTMORE HOTEL, LOS ANGELES, CALIF., MAY 7, 1947.

of the Biltmore Hotel. More than 400 members and guests attended. Master of ceremonies was C. E. McGinnis, chief boiler inspector of the city of Los Angeles, whose friendly wit and humor promoted the success of the occasion.

The following day, Friday, May 9, the Boiler Code Committee held one of its regular meetings in the Rennaissance Room of the Biltmore Hotel. H. B. Oatley, chairman of the Committee, presided. About 35 guests were present. Brief addresses of welcome were made by C. E. McGinnis, J. Calvin Brown, vice-president, A.S.M.E. Region VII, and K. V. King of Standard Oil of California. The regular meeting adjourned at 2:30 p. m. after which many left the hotel for points north and east.

Fuel Economy Conference Planned for Sept., 1947

AN international Fuel Economy Conference sponsored by the World Power Conference will be held Sept. 2 to 9, 1947, at The Hague, Netherlands, it has been announced.

Subjects for discussion will be the production, distribution, and utilization of fuels of all types, with special reference to wartime experiences and to developments realized since 1939 or now in prospect.

The conference is being arranged by the Netherlands National Committee which includes J. R. Ringers as honorary chairman, G. J. Th. Bakker as chairman, and J. C. van Staveren as second secretary.

American participation is being sponsored by the Executive Committee of the United States National Committee of which Gano Dunn, honorary member A.S.M.E., is chairman.

Application for membership in the conference may be addressed to H. C. Forbes, treasurer and secretary, Executive Committee of U. S. National Committee, World Power Conference, 4 Irving Place, New York 3, N. Y. Members will be furnished with advance copies of all papers to be presented and will be afforded an opportunity to purchase the bound transactions at reduced price.

A.S.M.E. Junior Committee Holds First Meeting

DONALD E. JAHNCKE, junior member A.S.M.E., plant-layout engineer, Plymouth Division, Chrysler Corporation, Detroit, Mich., was elected chairman of the A.S.M.E. Junior Committee at its organization meeting held at headquarters, May 16, 1947.

Following a general discussion of the problems faced by the junior engineer in industry and the opportunities offered to him by the A.S.M.E., the Committee agreed to study the E.J.C. reports on employer practice and collective bargaining as well as the "plan for engineers" (see page 619 of this issue) suggested by the Committee on Professional Status Development of the Junior Group of the Metropolitan Section, as the first steps in its attack on the junior problem.

The Committee will hold its next meeting on July 11, 1947.

Lecture Course Features 19th National Oil and Gas Power Conference at Cleveland, Ohio, May 21–24

BY vigorously following up an original idea for the 19th National Oil and Gas Power Conference of the American Society of Mechanical Engineers held at the Hotel Statler, Cleveland, Ohio, May 21–24, 1947, and attended by 500 engineers of the oil and gas power industry, the A.S.M.E. Oil and Gas Power Division triumphantly demonstrated how the Society may in yet another way serve the engineering profession.

Working on the theory that recapitulation of knowledge and current techniques in the various fields of mechanical engineering as well as announcement and discussion of new developments is the proper business of the A.S.M.E., the Oil and Gas Power Division scheduled a one-day lecture course for the day preceding official opening of the Conference. Three authorities were invited to review the technology of Diesel fuel oils in two-hour lectures given in morning, afternoon, and evening sessions. Not only was the response encouraging, it was overwhelming. Where mail registration indicated an attendance of 60 engineers, more than 100 enrolled for the lectures and participated enthusiastically in each of the discussions.

Success of the lectures surprised Division officers because they had been planned with some misgivings, first because registrants would have to stand the expense of an extra day in Cleveland if they were to participate in the technical program of the Conference and second, because a fee of $12 was being charged for members and $15 for nonmembers. In spite of these apparent drawbacks, reception of the lectures was so favorable that the Division has come to the conclusion that programs of this type answer a definite need of practicing engineers and should become a permanent feature of A.S.M.E. national meetings and conferences.

On the basis of the success of the subcommittee of the O.G.P. Division set up to study the idea of lecture courses as preliminary attractions to national conferences of the Division, it is likely that a follow-up course on lubrication may be a feature of the 1948 Conference.

Observers have commented that one of the reasons for the success achieved was the exceptional lucidity of the presentation which followed step by step the science and technology of Diesel fuel oils from the time the raw materials were taken from the earth to the final use in an engine. The lectures were described as a rare experience and the enthusiasm aroused by them, a spontaneous expression of approval.

The lectures were as follows: "Production of Diesel Fuel Oils," by C. A. Rehbein, Shell Oil Company, New York, N. Y.; "Physical and Chemical Characteristics of Diesel Fuel Oils," by R. D. Pinkerton, Sinclair Refining Company, East Chicago, Ind.; and "Combustion of Diesel Fuel Oils," by M. A. Elliott, Bureau of Mines, Pittsburgh, Pa.

Although the lectures were mainly in note form, they were recorded by a public steno-

HEADLINERS AT THE O.G.P. DIVISION BANQUET, THURSDAY, MAY 22
(*Left to right:* E. E. Johnson, Lee Schneitter, Edwin J. Schwanhausser, and S. R. Beitler, vice-president, A.S.M.E. Region V.)

rapher. The transcripts will be edited by the lecturers and published for distribution in the early fall to those who registered for the course. To others who may want copies, a nominal charge will be made to cover costs. As an aid to the Division in determining the number of copies required in excess of registration, members who expect to purchase copies are urged to send in their orders early.

In recognition of meritorious service to the O.G.P. Division and to the Society, each lecturer was given a set of books on petroleum technology at part of the ceremonies at the banquet on Thursday, May 22.

Exhibit Part of Conference

Thirty-four manufacturers of Diesel engines and related accessory equipment added to the interest of the Conference by staging a display of their products. The exhibits were comprehensive and educational. Many contained animated displays and working models of new products in the oil and gas power field.

Four Technical Sessions

The technical program consisted of ten papers presented at four sessions. The papers explored the fuel-supply situation, the design and application of various kinds of engine bearings, fuel injection, internally cooled supercharging, relation of fuel to smokeless engine operation, and the possibility of various vegetable oils as sources of Diesel engine fuel.

Also on the program were several inspection trips to plants of Cleveland manufacturing concerns. Two afternoons were devoted to visits to the N.A.C.A. Laboratories.

The Conference opened officially with a luncheon at which A. E. Wilson, president, Cleveland Technical Societies Council, and president of the Keal Kennedy Manufacturing Company as the main speaker, called for functional design of American automobiles.

"Modern automobiles look like shiny baubles with their useless strips of chrome trim," he said, "any good engineer could go up to a new automobile and remove pounds of steel that have nothing to do with the car's mechanism. Yet automobile plants are shut for lack of material. . . . . It's up to engineers to take high costs out of our products and to bring prices down to the size of the average person's pocketbook."

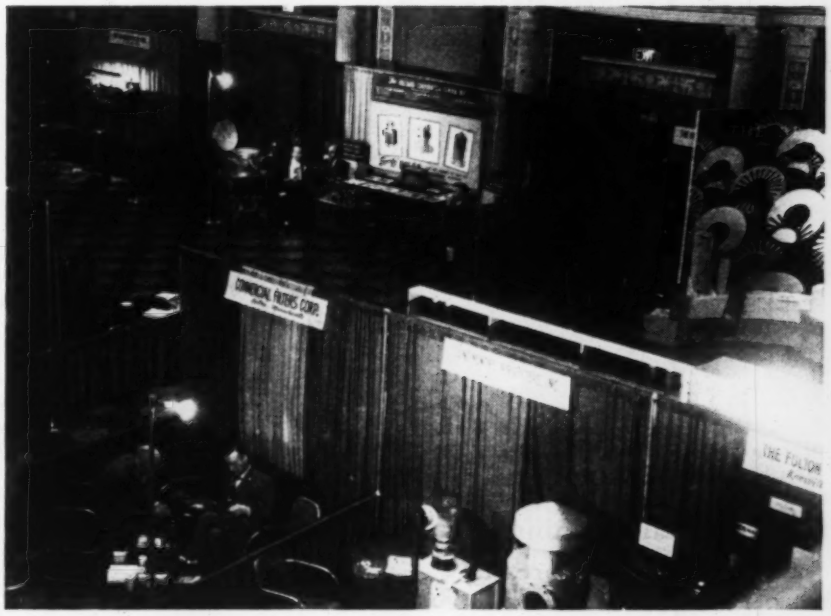
Fuel From Vegetable Oils

As co-author of a paper on use of vegetable oils as fuels for compression-ignition engines, R. L. Sweigert, member A.S.M.E., reported the possible use of peanut, soybean, and cottonseed oils. "They may be secured in considerable quantity from several agricultural areas of the United States," he said, but experiments have shown that their Btu value is "appreciably less than the Diesel oils."

Pistons Versus Jets

Speaking on "Some Aspects of Fuel-Injection Aircraft Engines," Israel Katz, jun. member A.S.M.E., professor, Sibley School of Mechanical Engineering Cornell University, said that piston engines must be designed to develop more power if they are to withstand the competition of jet aircraft power plants. The piston engines must also be mechanically simpler, easy to maintain, rugged, dependable, relatively light, and burn a cheap and readily available fuel, he said.

"Significant changes in piston engine design may well hold the tide in their favor for general service applications below speeds of 500 miles per hour," he added.



PART OF THE EXHIBIT AT THE 19TH NATIONAL OIL AND GAS POWER CONFERENCE HELD AT THE HOTEL STATLER, CLEVELAND, OHIO, MAY 21–24, 1947.

E. W. O'Brien Attends Banquet

The high point of the Conference was the banquet on Thursday, May 22, attended by 200 delegates. Lee Schneitter, chairman of the O.G.P. Division executive committee, introduced the toastmaster, E. J. Schwanhausser, member A.S.M.E., vice-president, Worthington Pump and Machinery Corporation and president of the Diesel Engine Manufacturers' Association. He in turn introduced a surprise guest, Eugene W. O'Brien, president A.S.M.E., who spoke briefly and humorously on the rigors of air travel. Concluding his comments seriously, President O'Brien outlined some of the major problems facing the engineering profession, such as the question of unionization, the role of the young engineer, and the desirability of strengthening and upgrading the professional tone of engineering services.

President O'Brien was followed by E. E. Johnson, General Electric Company, Schenectady, N. Y., main speaker of the evening, who talked on recent progress of engineering research. He named a host of new products and devices which reflect the inventive and manufacturing genius of the United States.

Division Honors Conference Authors

In ceremonies preceding banquet speakers, six authors were awarded the first O.G.P. Division certificates of merit to be presented for papers of exceptional merit presented at former conferences of the Division. Those honored were:

J. K. Salisbury, member A.S.M.E., General Electric Company, Schenectady, N. Y., for a paper on "The Basic Gas Turbine Plant and Some of Its Variants."

J. I. Yellott, member A.S.M.E., Locomotive Research Council, Baltimore, Md., for his paper on "The Effects of Pressure Loss on the Open Cycle Gas Turbine Power Plants."

M. A. Elliott, Bureau of Mines, Pittsburgh, Pa., for "Corrections of Measurements of Power Output of Diesel Engines at Standard Atmospheric Conditions."

S. A. Tucker, junior member A.S.M.E., McGraw-Hill Publishing Company, New York, N. Y., for "Gas Turbines—Present Status and Future Prospects."

Eric F. Lype, member A.S.M.E., Armour Research Foundation, Chicago, Ill., for "The Effects of Pressure Loss on the Open Cycle Gas Turbine Power Plant." (Co-author)

F. A. Firestone, consulting engineer, Washington, D. C., for "The Supersonic Reflectoscope for Inspecting Materials."

The A.S.M.E. St. Louis Section has invited the O.G.P. Division to hold the 1948 National Oil and Gas Power Conference in St. Louis, Mo. Since 1948 will mark the fiftieth anniversary of the introduction of the Diesel engine to the United States and since St. Louis is the site where the first engine was presented to the U. S. power industry through the efforts of Adolphus Busch, the 20th National Conference will be an event of no ordinary interest.

Committees

The following committees are credited with the success of the conference:

General Arrangements: George Codrington, honorary chairman; P. B. Jackson, chairman; E. B. Crankshaw, vice-chairman; Colin Carmichael, secretary; and E. R. McCarthy, treasurer.

Advisory Committee: E. B. Crankshaw, C. R. Sutherland, Warner Seeley, and H. M. Wilson.

Registration: E. R. McCarthy, C. R. Sutherland, and D. K. Wright, Jr.

Meetings: P. T. Eisele, Colin Carmichael, G. L. Tuve, Roger Bolz, and H. S. Colby.

Entertainment: Warner Seeley, K. L. Browne, and L. C. Cole.

Inspection Trips: J. E. Hacker, Wm. C. Dunn, Charles Smythe, P. B. Jackson, Robert C. Sessions, and R. F. Schaefer.

Exhibits: G. B. Longcoy, C. R. Sutherland, and G. H. Pfefferle.

Publicity: E. R. McCarthy and Colin Carmichael.

Ladies' Program Committee: Mrs. C. M. Hickox, Mrs. E. R. McCarthy, Mrs. E. B. Crankshaw, Mrs. C. W. Wilke, Mrs. R. R. Slaymaker, and Mrs. J. H. Gruver.

Experimental Training Unit at Fort Knox Impresses E.J.C. Representative

GOOD citizenship training as well as good basic military training for defense of the nation" is the conclusion of Stewart E. Reimel, member A.S.M.E., following a two-day inspection of the facilities and methods used by the Army for its Universal Military Training Experimental Unit at Fort Knox, Ky.

Mr. Reimel made the visit as official representative of the Engineers Joint Council. He was accompanied by scores of other visitors representing national organizations, who were invited by the Secretary of War to witness firsthand the kind of military training the Army was prepared to give young men, when and if the proposed compulsory-military-training law now before Congress should be enacted.

On the basis of what he observed at Fort Knox, Mr. Reimel stated, "I am convinced that the nation would benefit greatly should a universal military law be enacted and the type of training given at Fort Knox be extended to all trainees."

What the visitors found at Fort Knox was not a conventional military-training center but one transformed by a new approach to the problems and methods of training. Under the command of enthusiastic officers, 650 young men in the 18-year-old group specially selected to represent a cultural and mental cross section of the youth of the United States, were being indoctrinated in the fundamentals of national defense. In contrast to the "sink or swim" attitude of the old army, with its harsh discipline, forced conformity, submergence of personality, and seeds of disillusionment, the Fort Knox concept of basic training is one of graduated individual tasks and responsibilities selected to build confidence and individuality by giving consideration to the personal aptitudes of the trainees.

Blind obedience to orders is discouraged by emphasizing and teaching the reasons underlying them. Instead of harsh penalties, the demerit system, long a standard tool of the military academies, has been introduced as the basis for discipline. Because the training units are composed wholly of trainees of about the same age, the unwholesome features of the old methods have been eliminated. The proverbial "army talk" of the older regular Army men which tends to destroy cherished ideals of young men, has been discarded as an element in the basic military training. Visitors noted the decorous conduct of the trainees especially during the "chow call." There was no shouting and cursing. The conduct of the trainees was well above the average expected in 18-year-old young men and was in marked contrast to the mess-hour decorum usually associated with hardened soldiers.

EXPERIMENTAL BASIC MILITARY TRAINING AT FORT KNOX, KY.

The trainees are organized into four training companies of six platoons each with its battalion headquarters and headquarters staff. The organization within the companies varies to give training in each of the various Army branches. The faculty consists of officers and enlisted men of the regular Army under command of Brig. Gen. John M. Devine.

One of the signal achievements of the experimental program is the effect it has had on regular Army sergeants assigned to it. Many approached the program with a deep-rooted scepticism and a conviction that the basic concept was wrong and therefore doomed to failure. These men are now its greatest boosters.

Under the proposed Universal Military Training Law young men between the ages of 18 and 20 will obtain 6 months of training after the manner initiated at Fort Knox, and this would be followed by six additional months of similar training or by study or training in any of the following branches depending on the preferences of the trainee; regular Army, national guard, enlisted reserve corps, service academies, colleges, and universities.

E.J.C. Publishes First Part of Manual on Collective Bargaining for Professional Employees

PUBLICATION of Part I of a three-part "Manual on Collective Bargaining for Professional Employees" has been announced by the Committee on the Economic Status of the Engineer of the Engineers Joint Council.

The manual is a 64-page bulletin designed to give professional employees the background against which they may interpret and appraise the current developments in the field of labor relations. It is a source book of useful information on how to organize a bargaining unit for professional employees.

It has been prepared by the Engineers Joint Council to give professional employees a knowledge of their rights and responsibilities under the Wagner Act and to inform them about the theory and practice of labor organizations and collective bargaining as they function in business and industry. The Committee has treated this controversial subject as objectively as possible, keeping in mind that the decision to organize or not to organize and the choice of bargaining agency and a bargaining unit, to the extent permitted by the Wagner Act, rests with professional employees themselves.

Although the Manual applies specifically to the National Labor Relations Act of 1935 (Wagner Act), its study of the methods and tactics of the American labor movement, and the impact of labor unions organized by non-professional employees on the economic status of engineers, will provide valuable reference material for the future.

Part I of the Manual is composed of six chapters. After an analysis of the stated objectives of the Wagner Act, the industries covered by it, the rights guaranteed to employees, the unfair labor practices which employers may not engage in, and the agencies and procedures established to give effect to the public policy stated in the Act, the Manual proceeds to review the efforts of engineering and other societies to assist professional employees in the protection of their interests.

This is followed by a discussion of the current proposals to modify the Wagner Act suggested by the engineering societies to further the interests of professional employees, and a study of the course of action which have been taken by professional employees when they have been confronted with union representation disputes which often precede collective-bargaining actions in industry.

Chapter five examines the advantages and disadvantages of labor organizations restricted to employees of a single establishment or company as compared with labor organizations whose jurisdiction embraces a region or an industry. It also appraises the various types of labor organizations from the standpoint of structure, and discusses the benefits and limitations of affiliation with a national federation of labor.

The last chapter covers the conditions which must be met and the steps that may be taken by professional employees who find it desirable or necessary to establish an organization for collective bargaining.

The National Labor Relations Act, a sample constitution, membership application form, and election ballot are included as appendixes to the Manual.

The two remaining parts of the Manual still in preparation will deal with the following: Part II: Collective Bargaining, Mediation, and Arbitration. This bulletin will cover the purpose and content of collective bargaining; the process of negotiation and living under a contract, and the nature and place of mediation and arbitration in the set element of industrial disputes.

Part III will analyze objectives, structure and tactics of labor organization. It will present a brief history of the American Labor Movement, examine the structure and function of labor organizations, and portray union organizing tactics and strike strategy and tactics.

Copies of the Manual may be obtained from A.S.M.E. Headquarters. The price is $1 for Part I.

E.J.C. Named to National Commission of UNESCO

THE Engineers Joint Council was among seven organizations recently invited to name representatives to fill seven of the remaining seats on the National Commission for Educational, Scientific, and Cultural Cooperation, according to an announcement by Milton S. Eisenhower, chairman of the National Commission. The selection gives recognition to the part engineers play in the cultural life of the United States and tends to give balance to the membership of the Commission which is weighted heavily on the side of the social and pure sciences.

The National Commission is the first American group on nongovernmental organizations set up by the Department of State to aid in the selection of the American delegation to UNESCO (United Nations Educational, Scientific, and Cultural Organization). UNESCO was conceived in London in the fall of 1945 and was organized at a meeting held in Paris in November, 1946. Its permanent headquarters are now in Paris.

When finally constituted, the National Commission will be composed of 100 individuals, 60 of whom will represent nongovernment organizations, national in scope, such as societies, associations, and councils in the field of education, science, radio, arts, civic life, and the press, 25 of whom will represent various federal state and local authorities, and 15 of whom will represent the nation at large.

While the E.J.C. was among the early organizations considered for membership on the Commission, the engineering profession was passed over last fall when the first fifty organizations were named. Attention was then called by the E.J.C. to the lack of balance in the membership of the Commission caused by the absence of a spokesman for the engineering or applied sciences. The State Department indicated that the exclusion of the E.J.C. had been an oversight which would be corrected with the selection of the remaining ten organizations.

Membership on the Commission is not permanent but is to be reviewed annually to insure future rotation.

E.J.C. Committee Named to Aid State Department in International Relations

CLOSER LIAISON between the engineering profession and federal agencies devoted to better international relations is the object of a special committee recently appointed by E.J.C. The committee will be made up of one representative from each of the five constituent societies of E.J.C. It will be a consultative committee to the State Department and to the E.J.C. Committee on International Relations, of which Malcolm Pirnie, consulting engineer, New York, N. Y., member A.S.C.E., is chairman.

The committee was authorized by E.J.C. following the appearance before it of E. Theodore Arndt, of the U. S. State Department, as an observer representing William Benton, Assistant Secretary of State, who heads the Department of State Division of International Information and Cultural Affairs.

After lauding the co-operation which the State Department has had from the E.J.C. Committee on International Relations and declaring that there is increasing need for liaison between the State Department and the engineering profession, Mr. Arndt told E.J.C:

"Foreign countries are anxious to find out the U. S. 'know-how.' Requests come in daily for engineering knowledge. These requests are channeled through the State Department, and we would like to have the advice of engineers on how to handle these requests.

"The recent election of E.J.C. to UNESCO (United Nations Educational, Scientific, and Cultural Organization) is a step forward to recognize the contribution that engineers can render in the rehabilitation of the world."

Members of the consultative committee appointed are E. M. Hastings, president A.S.C.E., W. E. Wickenden, past-president A.I.E.E., Clyde Williams, president A.I.M.E., D. R. Yarnall, past-president A.S.M.E., and J. G. Vail, past-president A.I.Ch.E.

As pointed out by Chairman Pirnie of the International Relations Committee, availability of the members of this consultative committee will be helpful when requests for assistance are made by the Department of State on short notice, for it is expected that with the enlarged personnel, personal assistance of at least some members of the committee will be available at all times. Mr. Pirnie stressed this point in connection with a recent appearance he was called upon to make before the subcommittee of the Foreign Affairs Committee of the House of Rrepresentatives. With only 24 hours' notice, Mr. Pirnie appeared before the committee and made a presentation on behalf of the engineering profession on HR3342, known as the Mundt Bill, which is successor to the so-called Bloom Bill. The Bloom Bill failed of passage at the last session of Congress, and the Mundt Bill represents a revision of it which has eliminated the features which were objectionable to the engineering profession.

In his presentation before the House subcommittee, Mr. Pirnie, who followed Secretary of State George Marshall in testifying, stressed the following:

The best properly qualified engineering talent in the country, selected from private business and from government agencies, should be made available to other nations requesting aid of the United States in solving their domestic-engineering problems conducive to improved standards of living. Helping other countries to raise their standards of living is the new big frontier. Care must be exercised to avoid any erroneous assumptions by other countries that the technological superiority of the United States which resulted in defeat of the Axis powers should be sought solely in agencies of the government.

Any such assumption is false and dangerous, since the technical superiority of the United States resulted from maximum contribution to the war effort by technologists in private industry and consulting practice, working in full co-operation with technologists in agencies of government. In the interchange of American and foreign engineers, extreme care should be exercised, as provided by the Mundt Bill, to point up the completely co-operative efforts between the United States citizens engaged in free-enterprise activities and those who have devoted their lives to service in government bureaus and agencies, as contrasted with the practice among other nations in which progress in technology was, and is, directed and

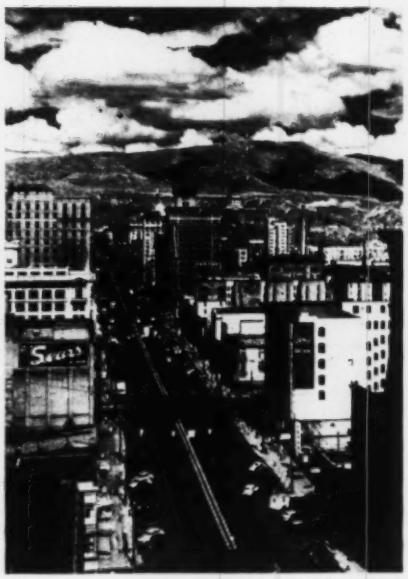
controlled by national government bureaus.

Through their experiences in World War II, engineers are convinced that no nation can successfully prosecute a war without calling upon its applied scientists to operate to the limit of their capacity. There is a corollary to that conviction. If engineers must be depended upon to fight a successful war, they have a commensurate responsibility to work with foreign engineers and governments in all efforts to prevent a future war. They therefore seek full co-operation in such programs and will do their best in any unaccustomed field to develop and spread sound information by which they can contribute to the development of better international understanding.

A.S.M.E. 1947 Fall Meeting Program Taking Shape

AS THE principal event on the early fall calendar of The American Society of Mechanical Engineers, the A.S.M.E. 1947 Fall Meeting to be held at the Hotel Utah, Salt Lake City, Utah, Sept. 1 to 4, 1947, is currently absorbing the attention of Society's planning committees and headquarters staff.

The summer season with its Semi-Annual Meeting and four national meetings of the Professional Divisions successfully concluded, center of interest has shifted to the A.S.M.E. 1947 National Parks Tour and the program of the Fall Meeting which is to be held during the centenary celebrations of the founding of Salt Lake City.



MAIN STREET, SALT LAKE CITY, UTAH, SCENE OF A.S.M.E. 1947 FALL MEETING

Professional Divisions have now indicated the number of sessions they will need, authors and papers have been followed up, speakers have been invited, topics suggested, social features planned, space and facilities reserved, and inspection trips scheduled. All that remains to be done to co-ordinate these essential elements of a well-balanced meeting is to produce "the program." But this is easier said than done.

Actually, at time of going to press, the A.S.M.E. 1947 Fall Meeting program is a mere outline which, except for scheduling technical sessions, luncheons, and dinners, reveals little else.

This is how the program looks:

Monday, Sept. 1: At noon keynote luncheon at which Euguene W. O'Brien, president A.S.M.E., will be the speaker; technical sessions on metals engineering and education in the afternoon; a dinner and a management session in the evening.

Tuesday, Sept. 2: Technical session on heat transfer and hydraulics in the morning; a general luncheon at the Newhouse Hotel; inspection trip to the Bingham Mine in the afternoon; and a joint dinner with the A.I.M.E. Utah Section at which Clyde E. Williams, president A.I.M.E., will be the speaker.

Wednesday, Sept. 3: Technical sessions on materials handling and fuels in the morning; joint luncheon with the Sons of the Utah Pioneers, followed by inspection trips in the afternoon, and the A.S.M.E. Fall Banquet in the evening.

Thursday, Sept. 4: Technical sessions on power and the process industries in the morning; joint luncheon with the Kiwanians, followed by inspection trips to near-by canyons.

A more complete program will be published in the August issue of MECHANICAL ENGINEERING.

A.S.M.E. Calendar

of Coming Events

Sept. 1–4, 1947
A.S.M.E. Fall Meeting
Salt Lake City, Utah

Sept. 8–9, 1947
A.S.M.E. Instruments and Regulators Division Meeting
Chicago, Ill.

Oct. 6–8, 1947
Petroleum Committee of the A.S.M.E. Process Industries Division Meeting
Houston, Texas

Oct. 20–22, 1947
A.S.M.E. Fuels Division Meeting
Cincinnati, Ohio

Dec. 1–5, 1947
A.S.M.E. Annual Meeting
Atlantic City, N. J.

March 1–5, 1948
A.S.M.E. Spring Meeting
New Orleans, La.

May 30–June 5, 1948
A.S.M.E. Semi-Annual Meeting
Milwaukee, Wis.

Sept., 1948
A.S.M.E. Fall Meeting
Portland, Ore.

Nov. 28–Dec. 4, 1948
A.S.M.E. Annual Meeting
New York, N. Y.

Applied Mathematics Symposium Planned

THE A.S.M.E. will be one of the cosponsors of the Symposium on Applied Mathematics sponsored by the American Mathematical Society, to be held at Brown University, Providence, R. I., Aug. 2 to 4, 1947. Subject of the symposium will be "Nonlinear Problems in the Mechanics of Continua."

Other organizations sponsoring the symposium are the American Institute of Physics and the Institute of the Aeronautical Sciences.

Copies of the program and reservation cards may be obtained by writing to Prof. W. Prager, Brown University, Providence 12, R. I.

A.S.M.E. Aviation Division Holds Successful Annual Meeting

THE 1947 Aviation Meeting, sponsored by the Aviation Division of The American Society of Mechanical Engineers, and held at the University of California at Los Angeles, Calif., May 26–29, 1947, was attended by more than 1500 engineers who took advantage of the unique program of evening sessions to hear and discuss 40 papers on aviation, applied mechanics, metals, heat transfer, management, instruments and regulators, rubber and plastics, guided missiles, fuels and lubricants, and production and tooling.

A more complete report of the meeting will be published in the August issue of MECHANICAL ENGINEERING.

A.S.C.E. Conducts Survey on Teaching Positions

THE American Society of Civil Engineers is currently conducting a survey of educational requirements, responsibilities, and salaries of each position in the teaching field of civil engineering. Questionnaires have been mailed to all colleges and universities on the E.C.P.D. accredited list of schools giving courses in civil engineering. The information will be used by the A.S.C.E. Committee on Salaries to evaluate the minimum requirements for appointment to instructing staffs.

G. F. Bateman Honored

GEORGE F. BATEMAN, member A.S.M.E., and dean of the Cooper Union School of Engineering, was awarded a Certificate for Meritorious Service at commencement exercises of the institution in recognition of his 40 years on the Cooper Union faculty. The presentation was made by Gano Dunn, honorary member A.S.M.E., president of the J. G. White Engineering Corporation, New York, N. Y.

LORD DUDLEY GORDON, NEW HONORARY MEMBER A.S.M.E.

I.M.E. President Honored by A.S.M.E.

LORD DUDLEY GORDON, president of The Institution of Mechanical Engineers, and chairman of J. and E. Hall, Limited, Dartford Iron Works, Dartford, England, has been elected to honorary membership in The American Society of Mechanical Engineers, it has been announced.

Certificate of honorary membership was presented to Lord Dudley Gordon by A. G. Christie, past-president and honorary member, A.S.M.E., at a ceremony during the centenary celebrations of the Institution, held June 8 to 13, 1947.

Lord Dudley Gordon is an authority on refrigeration and is generally responsible for the land-type refrigerating installation developed by his firm.

Lord Dudley Gordon has been a member of council of the Institution since 1940 and was vice-president of the British Association of Refrigeration, British Engineers' Association, and the Federation of British Industries.

British Industry to Hold Exhibition

THE products and techniques of Britain's industrial ingenuity will be on display during the first postwar Engineering and Marine Exhibit to be held in the Main and National Halls at Olympia, London, August 28 to Sept. 13, 1947.

Lord Dudley Gordon, honorary member A.S.M.E., president of the Institution of Mechanical Engineers, is honorary president of the exhibition.

According to the notice received, the exhibit "will present at least one interesting refutation of the carefully circulated story that British industry—tied by crippling controls, shortages of raw material, man power, and fuel—has neither the resilience nor the initiative to weather the international marketing storms" of the postwar era.

I.I.R. Division Plans Second Annual Meeting

THE second annual meeting of the Industrial Instruments and Regulators Division of The American Society of Mechanical Engineers will be held in co-operation with the A.S.M.E. Chicago Section at the Congress Hotel, Chicago, Ill., Sept. 8 and 9, 1947.

The first day of the meeting will be devoted to two technical sessions and a banquet. The second day will be given over to meetings of the technical committees of the Division.

Following the precedent set in 1946, the meeting will be held in conjunction with the annual meeting and exhibit of the Instrument Society of America. The I.S.A. exhibition will open on Monday, Sept. 8, and continue to Friday, Sept. 12. It will include exhibits of more than 100 manufacturers of industrial instruments and devices for measurement, inspection and control, and those promised by the Armed Services and government laboratories.

The I.S.A. technical program which follows the A.S.M.E. program will consist of six sessions on the following topics: Plant instrument practices; new instrumentation developments; quality control; process control; industrial use and measurement of radioactive materials; and chemical concentration measurement and control. No simultaneous sessions are planned. Registration for the A.S.M.E. and the I.S.A. programs will be free.

Because the Chicago hotel situation is expected to be tight, members planning to attend the meeting are urged to make reservations early by writing to Mr. Amico, Sales Manager, Congress Hotel, Chicago, Ill. Reference should be made to the A.S.M.E. meeting.

A.S.M.E. Members Contribute to Management Congress

MEMBERS and Fellows of the A.S.M.E. are to contribute 10 of the 25 papers to be presented by the American Delegation to The Eighth International Management Congress to be held at Stockholm, Sweden, July 3 to 8, 1947.

The Congress is sponsored by the International Committee of Scientific Management, of which William L. Batt, past-president and honorary member, A.S.M.E., is president. Its purpose is to state and appraise the progress made in management, to exchange ideas and experiences, and to promote education in scientific management.

World management congresses were held previously in Prague (1924), Brussels (1925), Rome (1927), Paris (1929), Amsterdam (1932), London (1935), and Washington, D. C. (1938).

The congress will be opened officially with an address by Mr. Batt on "Management's Contribution to a Better Standard of Living."

Papers contributed by members and Fellows of the A.S.M.E. follow:

Business Management in the U.S.A. (1939–1946), by Alvin E. Dodd, member A.S.M.E., president, American Management Association.

Evolution in Organization During the Past Decade, by Harry Arthur Hopf, member A.S.M.E., H. A. Hopf and Company, Ossining, N. Y.

Progress in Production in the U. S. A., by L. C. Morrow, member A.S.M.E., editor, *Factory Management and Maintenance*, McGraw Hill Publishing Company, Inc., New York, N. Y.

Significance of the Productivity of Labor, by John A. Willard, member A.S.M.E., Bigelow, Kent, Willard & Company, New York, N. Y.

Education of Industrial Executives in Scientific Management, by Wallace Clark, Fellow A.S.M.E., Wallace Clark & Company, New York, N. Y.

Formal Education in Scientific Management, by Erwin H. Schell, member A.S.M.E., professor, Massachusetts Institute of Technology, Cambridge, Mass.

Progress in Industrial Work Simplification, by Allan H. Mogensen, Harold B. Maynard, member A.S.M.E., president, Methods Engineering Council, Pittsburgh, Pa., and David B. Porter, member A.S.M.E., professor, New York University, New York, N. Y.

Progress in Quality Control, by Joseph M. Juran, member A.S.M.E., professor, New York University, New York, N. Y., and Ralph E. Wareham.

Management and the Home, by Lillian M. Gilbreth, Fellow A.S.M.E., and president, Gilbreth, Inc., Montclair, N. J.

United States participation in the Congress was sponsored by The National Management Council of which John A. Willard, member A.S.M.E., is chairman.

C. E. Davies, secretary A.S.M.E., will participate in the Congress as one of the United States delegates.

WILLIAM L. BATT (*left*) OUTLINES TO W. AVERELL HARRIMAN, SECRETARY OF COMMERCE, AIMS OF UNITED STATES DELEGATION TO EIGHTH INTERNATIONAL MANAGEMENT CONGRESS IN STOCKHOLM, SWEDEN, TO BE HELD JULY 3–8, 1947

Meetings of Other Societies

July 16–18
American Society of Civil Engineers, annual convention, Hotel Duluth, Duluth, Minn.

July 21–25
American Water Works Association, annual conference, San Francisco, Calif.

August 7–8
Institute of the Aeronautical Sciences, Inc., annual summer meeting, Los Angeles, Calif.

August 26–29
American Institute of Electric Engineers, Pacific general meeting, San Diego Hotel, San Diego, Calif.

September 3–6
Technical Association Pulp and Paper Industry, Fundamental Research Meeting, Appleton, Wis., Institute of Paper Chemistry

September 8–12
Instrument Society of America, second annual conference and exhibit, The Stevens Hotel, Chicago, Ill.

September 15–19
American Chemical Society, 112th national meeting, New York, N. Y.

September 17–18
Society of Automotive Engineers, Inc., national tractor meeting, Hotel Schroeder, Milwaukee, Wis.

September 17–26
National Machine Tool Builders' Association, machine tool show, Dodge Chicago Plant, Chicago, Ill.

September 22–25
Association of Iron and Steel Engineers, annual meeting, Hotel William Penn, Pittsburgh, Pa.

September 29–Oct. 1
American Institute of Chemical Engineers, regional meeting Hotel Statler, Buffalo, N. Y.

Indian Engineers Celebrate Silver Anniversary

THE Institution of Engineers in India recently celebrated the 25th anniversary of its founding by publication of a Silver Jubilee Volume. No social functions were planned because of the difficult postwar conditions.

The Institution was formed in 1920 on recommendation of the Indian Industrial Commission. Since that time the membership has grown from 138 to more than 3000. The Institution was granted a royal charter in 1935 and was the first professional institution in India to be so honored.

The Institution concerns itself with such professional matters as technical education, Indian standards, employment of Indians on Indian engineering projects, and cultivation of original Indian contributions to engineering and science. The Institution fosters registration of engineers and serves on advisory boards of most of the engineering colleges and institutions of India.

In the foreword of the Silver Jubilee Volume, S. B. Joshi, honorary secretary of the Institution, says, ". . . . . the future of India lies in the hands of its engineers who should have a place not only in the preparation and execution of engineering projects, but also in the central and provincial cabinets, legislatures, municipalities, and in the central administration of government and public concerns. Indian engineers have a heavy responsibility. We have to build India of our dreams with very limited resources . . . . . It is gratifying to note that the Indian engineers are beyond all considerations of caste, community, or race. In the midst of fratricidal strife, the unity of purpose of Indian engineers gives a ray of hope that penetrates darkness and enables us to look with confidence at the future."

Sheffield Scientific School to Mark Centennial

THE Sheffield Scientific School of Yale University, New Haven, Conn., one of the first university divisions of instruction and research in science to be established in the United States, will celebrate the one hundredth anniversary of its founding in October, 1947, it has been announced by Dr. Charles Seymour, president of the University.

The ceremonies will culminate in a University convocation on Oct. 17, at which honorary degrees will be conferred upon distinguished men of science.

The centennial coincides with a fundamental reorganization of the Sheffield Scientific School. The undergraduate bodies and faculties formerly divided between the sciences and the humanities have been consolidated. The School has now become the division of science of the University and is responsible for graduate instruction and general promotion of science.

Amalgamation of British Engineering Societies Announced

ON April 22, 1947, announcement was made of the amalgamation of the Institution of Automobile Engineers with The Institution of Mechanical Engineers. The date of the amalgamation was given as April 13, 1947. On that date The Institution of Mechanical Engineers created an Automobile Division, the efforts of which will be devoted to automotive engineering. At the same time, an agreement went into effect whereby the corporate members of The Institution of Automobile Engineers became corporate members of The Institution of Mechanical Engineers, in appropriate grades of membership.

Under the terms of the amalgamation, the Automobile Division will retain a large degree of autonomy. It will be managed, under general direction of the Council of The Institution of Mechanical Engineers, by the council of the Automobile Division.

The Royal Charter of The Institution of Automobile Engineers was surrendered, but members of the Automobile Division retain the right to use the title "chartered automobile engineer" as well as "chartered mechanical engineer." Subsequent admission to the Automobile Division will be open to members of The Institution of Mechanical Engineers only, and applications will be referred to the Council of the Automobile Division for approval.

In Great Britain "royal charter" bestows legal recognition on professional organizations. Membership in a chartered organization is equivalent to registration under state laws in the United States.

Connecticut Sections Elect W. F. Thompson to Conn. Technical Council

AT a meeting of the General Committee of Connecticut Sections of The American Society of Mechanical Engineers, Willis F. Thompson, member A.S.M.E., and vice-president, Wescott and Mapes, Inc., New Haven, Conn., was elected A.S.M.E. delegate to the Connecticut Technical Council.

National Conference on Industrial Hydraulics Planned

THE third annual meeting of the National Conference on Industrial Hydraulics (formerly the Hydraulic Machinery Conference) will be held at the Hotel Continental, Chicago, Ill. October 16 and 17, 1947.

The conference is sponsored by Armour Research Foundation and the Graduate School of Illinois Institute of Technology, Chicago, Ill., in co-operation with the Western Society of Engineers and the Chicago sections of the Society of Automotive Engineers, American Society of Civil Engineers, and The American Society of Mechanical Engineers.

The subjects of the four half-day sessions will be cavitation, industrial application of hydraulics, automotive fluid transmission, and hydraulic controls.

Additional information may be obtained from Dr. V. L. Streeter, Armour Research Foundation, Technology Center, Chicago 16, Ill.

L. D. Gardner to Receive 1947 Guggenheim Medal

LESTER DURAND GARDNER, associate A.S.M.E., and chairman of the board, Institute of the Aeronautical Sciences, has been awarded the Daniel Guggenheim Medal for 1947 for "outstanding achievement in advancing aeronautics, particularly for his conception and organization of the Institute of the Aeronautical Sciences."

The Daniel Guggenheim Medal is a joint award of The American Society of Mechanical Engineers, the Society of Automotive Engineers, and the Institute of the Aeronautical Sciences. It was made possible by a gift of the Daniel Guggenheim Fund for the Promotion of Aeronautics. The award is administered by the United Engineering Trustees, Inc.

A.S.T.M. Elects 1947–1948 Officers

ELECTION of officers of the American Society for Testing Materials for 1947–1948 was announced at the fiftieth annual meeting of the A.S.T.M., held in Atlantic City, N. J., week of June 16, 1947.

Those elected were: president, T. A. Boyd, Research Laboratory Division, General Motors Corporation, Detroit, Mich; vice-president for two years, J. G. Morrow, metallurgical engineer, The Steel Company of Canada, Limited, Hamilton, Ontario, Can.; directors for three years, Truman S. Fuller, General Electric Company, Schenectady, N. Y.; E. G. Ham, John A. Manning Paper Company, Inc., Troy, N. Y.; James J. Laudig, Delaware, Lackawanna, and Western Railroad Company, Scranton, Pa.; H. L. Maxwell, supervisor of general consultants, E. I. du Pont de Nemours and Company, Wilmington, Del.; and L. J. Trostel, General Refractories Company, Baltimore, Md.

New Graduate Fellowship Announced

RESEARCH fellowship in the metallurgy of nickel, copper, platinum, or alloys containing these metals, has been established at the Johns Hopkins University by the International Nickel Company. The fellowship amounting to $1900 will be awarded for the first time in September, 1947.

Specific subjects for investigation include the production, heat-treatment, purification, metallurgy, electroplating, and recovery of these metals, as well as investigation into their mechanical and electrical properties, corrosion resistance, and heat-transfer coefficients. While working on his chosen research problems the recipient can be completing courses for an advanced degree. It is anticipated that this fellowship will be most applicable to the work of students in the fields of mechanical, chemical, or electrical engineering.

For further information write to the Dean of Engineering, The Johns Hopkins University, Baltimore 18, Md.

Juniors Propose Plan for Engineers

ON May 14 the Committee on Professional Status Development of the Junior Group of the A.S.M.E. Metropolitan Section, presented its "Plan for Engineers" to the Metropolitan Section at a meeting held at the Engineering Societies Building, New York, N. Y.

This plan was the result of study over a six-month period to determine a solution to the professional and economic problems facing the engineering profession, without respect to existing or proposed legislation. The plan proposes a society paralleling the existing technical societies, but requires membership in one of the technical societies. Except for this prerequisite, membership in the new organization is optional. It proposes direct management liaison, rating of members if they so desire, establishment of standards, an effective public-relations program and many other features, which purport to benefit engineers and engineering.

The proposed plan was subjected to severe criticism by older members present, many of whom questioned the facts upon which the plan was based as well as the philosophy behind many of the innovations which it introduced.

Copies of the plan are available and may be obtained for 15c a copy or two for 25c from the Junior Group Committee on Professional Status Development, Metropolitan Section, A.S.M.E. Headquarters, 29 West 39th St., New York 18, N. Y.

A.S.M.E. Fellow and Members Honored by Stevens Institute

HONORARY degrees of doctor of engineering were conferred by the Stevens Institute of Technology, Hoboken, N. J., on Harry T. Woolson, Fellow A.S.M.E., and Philip Sporn, member A.S.M.E., and John L. Cox, member A.S.M.E. at the commencement exercises held June 7, 1947, at the Institute.

Mr. Woolson is vice-president of the marine division of the Chrysler Corporation and president of the Chrysler Institute of Engineering, Detroit, Mich.

Mr. Sporn is executive vice-president of the American Gas and Electric Service Corporation, New York, N. Y.

Mr. Cox, is chief engineer of the Midvale Company, Philadelphia, Pa.

Actions of the A.S.M.E. Executive Committee

At a Meeting Held at Headquarters May 14, 1947

A MEETING of the Executive Committee of the Council was held in the rooms of the Society May 14, 1947. There were present: Eugene W. O'Brien, chairman, F. S. Blackall, Jr., A. C. Chick, A. R. Mumford, C. E. Davies, secretary, and Ernest Hartford, executive assistant secretary.

Awards for 1947

Upon recommendation of the Board on Honors, the following awards for 1947 were approved:

A.S.M.E. Medal to Paul Walter Kiefer, chief engineer, motive power and rolling stock, New York Central System, New York, N. Y.

Holley Medal to Raymond D. Johnson, Fort Lauderdale Fla.

Worcester Reed Warner Medal to Arpad Ludwig Nadai, consulting engineer, Westinghouse Research Laboratories, East Pittsburgh, Pa.

Spirit of St. Louis Medal to John Knudsen Northrop, president and chief engineer, Northrop Aircraft, Inc., Hawthorne, Calif.

Melville Prize Medal for Original Work to Raymond Constantine Martinelli, engineer, general engineering and construction laboratory, General Electric Company, Schenectady, N. Y., for his paper "Heat Transfer to Molten Metals."

Applied Mechanics Reviews

The secretary was authorized to sign a contract with the Office of Naval Research, subject to review by the Managing Committee of the *Applied Mechanics Reviews*, covering Navy Department support of the proposed publication.

Topic for 1948 Charles T. Main Award

Upon recommendation of the Board on Honors the following topic for the 1948 Charles T. Main Award was approved: Relation of Invention to Engineering.

Certificates of Award

The issuance of Certificates of Award to the following members was approved: Arthur H. Cannon, H. C. R. Carlson, R. W. Flynn, J. N. Landis, A. R. Mumford, C. A. Hescheles, and W. H. Larkin.

Appointments

The following appointments were approved:

Gifts and Bequests: A. R. Cullimore, I. E. Moultrop, H. R. Westcott.

Special Research Committee on Fluid Meters: E. E. Stovall.

Special Research Committee on Screw Thread Strength: John E. Davey.

A.S.A. Section Committees on Ventilation Code and Exhaust Systems Code: Arthur C. Stern.

Engineers Council for Professional Development: James W. Parker.

United Engineering Trustees, Inc.: George L. Knight.

Hoover Medal Board of Award: D. W. R. Morgan.

Washington Award Commission (Western Society of Engineers): William H. Oldacre.

Sections

Shotpeening Subject at Akron-Canton Section

On May 22 at the Woman's Club, Akron, Ohio, John C. Straub, spoke on "Shotpeening." He presented the fundamentals of the subject, the methods of peening in production and discussed the types of equipment and their advantages and disadvantages in modern production practices and methods. Mr. Straub also cited many applications of shotpeening in present manufacture. Thirty-three were present.

Anthracite Lehigh Valley Section Hears Talk on Electronic Tubes

On May 23 at Lafayette College, Easton, Pa., forty-three members and guests heard a talk on "Electronic Tubes in Industry," by B. D. Bedford of the General Electric Company. Mr. Bedford discussed the types, sizes, and uses of the mercury-vapor rectifier and inverter, and described with the aid of slides their use in resistance welding, induction heating, dielectric heating, and general power conversion.

The student members of Lafayette College Branch and Lehigh University branch entertained members of the Section at a "Get Acquainted Smoker" at the Old Bethlehem Steel Club, Hellertown, Pa., on May 15. R. H. Porter, member A.S.M.E., presided. The speaker was Col. James L. Walsh, Army Ordnance Association. Colonel Walsh made a plea for all engineers to apply at least a part of their time to thinking about ways of insuring peace. He explained the tremendous cost of war, successfully waged in a large measure by the efforts of our engineers, and concluded that if engineers can contribute so effectively to the prosecution of a war they must also be able to contribute as effectively in preventing it. Sixty student members and 30 members were present.

Baltimore Section Visits Naval Experiment Station

On April 12 one hundred members accepted the invitation of Capt. W. D. Leggett, Jr., director of the Naval Experiment Station, Annapolis, Md., to view the facilities of the Station. The trip proved very interesting, but the size of the installation prevented everyone from seeing all of the Station. Many chose special projects, such as the Hill Project with its H_2O_2 experimental work, according to their special interests. After the trip the group assembled for lunch at the officers' club and heard a talk by Captain Leggett on the job of the Station, and an address by Vice-Admiral Carl W. Mills on the economic value of keeping the fleet in maintenance as insurance against another necessity for its use. The cost of keeping the fleet up, he said, is a very small fraction of the original cost or the expense of duplicating it. P. J. Kiefer, member A.S.M.E., of the Postgraduate School, presided at the luncheon and introduced to the members Capt. Peter W. Haas, Jr., executive officer of the Station; Dean Ford L. Williamson; Capt. William W. Cone; Capt. Paul B. Koonce, counsel; Capt. Joseph M. P. Wright; Capt. Herman A. Spanagel; and Capt. John Fradd.

The last meeting of the current season was held at the Engineers Club on May 26. One hundred members and guests were present to hear E. E. Parker, assistant design engineer of the Turbine Engineering Division, General Electric Company. Mr. Parker's talk accomplished the dual purpose of bringing those present up to date on recent developments in the field of steam turbines, and with slides, effecting a "conducted tour" of a turbine-manufacturing plant.

A. R. C. Markl, Speaker at Boston Section

On May 22 at Northeastern University, Boston, Mass., an audience of 80 heard a talk entitled "An Engineering and Economic Comparison of Welding Elbows and Miter Bends for Piping Systems," by A. R. C. Markl, Tube Turns, Inc. Mr. Markl covered a series of tests on welding elbows and miter bends, both with and without internal pressure when subjected to bending in the plane and at right angles to the plane of bending. The results showed conclusively that welding elbows were superior to miter bonds for bursting stresses, bending stresses under fatigue test (not endurance limits but limited cycle fatigue strength), and hydraulic characteristics. Comparative installation and operational costs were also considered. Slides were shown to illustrate the fatigue equipment and the results of tests.

Central Iowa Section Hears Talk on Fluid-Seal Development

On May 7 at the Hotel Maytag, Newton, Iowa, an audience of 110 heard a talk on "Fluid Seal Development at Maytag," by T. R. Smith, director of research, Maytag Company. Mr. Smith told of the development of several types of hydraulic seals developed by the use of the O ring, first for airplane control cylinders during the war, and later adaptations for other types of equipment.

Past-Chairmen's Night at Cincinnati Section

Sixty-two members and guests assembled at the Wyoming Golf Club, Wyoming, Ohio, on May 21, for dinner and the annual meeting of the Section. Eugene W. O'Brien, president A.S.M.E., flew from Atlanta, Ga., and spoke informally to the audience, discussing preliminary and as yet unpublished results of the Engineers Joint Council Survey. President O'Brien stressed the importance to industry, the profession, and to the Society, of working and co-operating with the young engineering graduates. He pointed to the generally excellent results obtained to date by those Sections which have established special junior member activities, and described the active program now under way at Headquarters in New York

Ten past-chairmen were honored guests namely, C. W. Luhn, A. C. Pletz, D. S. Brown, E. J. Martin, E. H. Schubert, E. S. Sauerbrunn, E. H. Mitsch, Hans Ernst, J. G. Matrin, and Mario Martellotti. Samuel R. Beitler, vice-president, A.S.M.E. Region V, presented a Certificate of Award to Mario Martellotti, past-chairman of the Section, in recognition of his outstanding service.

Heavy Industry Discussed at Dayton Section

On April 23 at the Engineers' Club of Dayton, Dayton, Ohio, W. Trinks, member A.S.M.E., consulting engineer, Jones and Laughlin Steel Company, addressed an audience of 55 on the subject "Heavy Industry." Professor Trinks said that increased productivity of labor through the use of technological developments and greater capital investment per worker has enabled heavy industry to pay labor more without increasing prices. The mechanical engineer, he said, has been an important factor in the advances in heavy industry. He declared that the American steel industry has expanded considerably, despite public demand currently surpassing the output.

Delaware Sub-Section Host at Joint Meeting

On May 21 the Sub-Section was host at a joint dinner meeting in the Brown Vocational High School, Wilmington, Del., with the A.I.E.E., A.I.Ch.E., and the A.S.C.E. This meeting was for the purpose of encouraging members of the engineering societies to take a more active part in the solution of present-day problems. Approximately 125 engineers were present to hear William L. Batt, past-president and honorary member, A.S.M.E., and president of SKF Industries, Inc., Philadelphia, Pa., speak on "The Engineer in Today's World." In his talk Mr. Batt said that the war-torn countries were looking to America, with her technical and scientific skills, for the building of economic stability, and that the only solution to world peace rests in the contributions of the engineering profession. Walter Locke, of Edge Moor Iron Company, presided at the dinner and meeting.

Greenville Section Meets Clemson College Branch

On April 24 in the Y.M.C.A. Building, Clemson, S. C., a joint dinner meeting of the Section and Clemson College Branch was held. The speaker was Merrill Scheil, chief metal-

lurgical engineer, A. O. Smith Corporation, Milwaukee, Wis., who gave an illustrated lecture on "Corrosion Fatigue in Metals in the Paper and Chemical Industries," and the "Welding of Alloy Metals." A discussion followed, led by the speaker, Walter K. Graham, executive administrator, and Henry Smitz, paper-mill equipment sales engineer, R. O. Smith Corporation. Among the 85 present were Dr. S. B. Earle, past vice-president and fellow, A.S.M.E., dean of the school of engineering, Clemson College, and E. E. Williams, vice-president, A.S.M.E. Region IV.

Officers nominated for the season of 1947–1948 were: James W. Vaughn, Jr., chairman; John A. Whitehurst, vice-chairman; and Ralph S. Pruitt, secretary-treasurer.

Annual Ladies' Night at Kansas City Section

The annual ladies' night meeting was held on May 12 at the University Club, Kansas City, Mo. After dinner the audience heard Rev. Robert A. Martin, clergyman of the Episcopal Church, speak on the subject "Human Highways."

At the business meeting Harold E. Manual was elected chairman for the new year, and Harold Grasse was elected secretary.

Mid-Continent Section Elects New Officers

The following officers have been elected to serve for the coming season: Francis J. Daasch, chairman; A. J. Hanssen, secretary; Carl A. Stevens, treasurer. The following vice-chairmen will serve in the areas covered by the Section: for the Tulsa area, James A. Wilson; Oklahoma City, Prof. Merl D. Creech; Bartlesville, Chester Fanshier; Amarillo, L. B. Jackson; Fayetteville, Prof. R. S. Paddock; Stillwater, Prof. H. G. Thuesen; and Shreveport, James Carmichael. Executive committee members are: D. O. Barrett, D. A. Cant, R. A. Colgin, D. E. Foster, C. O. Glasgow, J. H. Keyes, Orval Lewis, and W. Fred Stewart.

North Texas Section Hears C. J. Eckhardt

On May 12 in the D. P. & L. Co. auditorium, Dallas, Tex., Prof. Carl J. Eckhardt, Jr., member A.S.M.E., professor of mechanical engineering, University of Texas, spoke on "Student Selection and Guidance." Professor Eckhardt's lecture was illustrated, and showed the accurate results obtained from entrance examinations. He said that the proper interpretation of these examinations enables students to choose the course of study and life-work best suited to their aptitudes. Twenty-five were in the audience.

Ladies' Night at Raleigh Section

On May 16 at the Carolina Inn, Chapel Hill, N. C., 22 members and 18 visitors heard a talk on "Magic," by Hal S. Crain. This was ladies' night, and the audience was greatly entertained by Mr. Crain's magical experiments with cards, books, numbers, etc. Favors were given to the ladies in the audience. A short business session followed at which time the officers for the coming season were elected.

St. Joseph Valley Section Elects Officers for New Season

On May 13 the annual election of officers for the coming season was held at the Engineers Club, South Bend, Ind. The following were elected: G. R. McNeile, chairman; W. McKean White, Jr., secretary-treasurer; C. O. Harris, vice-chairman in charge of program; Bill Maddock, vice-chairman in charge of membership. R. C. Fitch, immediate past-chairman, becomes one of the directors, together with O. E. Zahn, C. C. Wilcox, and C. R. Egry.

Southern California Section Hears Talk by E. S. Lee

An audience of 103 assembled at the Rio Hondo Country Club, Los Angeles, Calif., to hear Everett S. Lee, member A.S.M.E., general engineering and consulting laboratory, General Electric Company, speak on "What's New in Science and Engineering." Mr. Lee explained the development of the various General Electric measuring devices, calculating machines, etc., showing the initial machines and the latest equipment developed. All diagrams and methods were illustrated and fully explained.

On May 15 at the Rodger Young Auditorium, Los Angeles, Calif., the subject discussed was "Plastics as Engineering Materials." Wm. J. Dewar of the Plastic Industries Technical Institute, discussed compression and transfer molding of thermosetting materials; Clinton C. Booth of the Glenn H. Taylor Company, discussed plastic laminates; T. W. Kerr of the Plastic Process Company talked on extrusion molding of thermosplastic materials; and John L. Taylor, Aladdin Plastics, Inc., discussed injection molding of thermoplastic materials. Displays of products used in industry produced by the methods described were viewed by the audience of 89.

Southern Tier Section Has Dinner Meeting

The monthly dinner meeting of the Section was held on May 26 at the Arlington Hotel, Binghamton, N. Y. The speaker was L. T. Weagle, manager of the specialty products division, Radio Corporation of America. In his talk Mr. Weagle said that the basic science of luminescent materials is still a mystery. Twenty thousand different synthetic phosphors were synthesized by R.C.A. in their search for the proper materials to be used in television cathode-ray tubes. He said that the fluorescent-lamp industry is a by-product of this work, and that the rapid development of radar during the war was due to this basic research in former years. Mr. Weagle described and displayed the chemical and physical properties of a great variety of luminescent phosphors. Their uses in television, medical, display, and novelty fields were also discussed and illustrated. Walter G. Baird, chairman, presided, and announced the following officers for the coming season: Richard Kinsman, chairman; Raymond W. Ramage, vice-chairman; William Stutske, secretary. Thirty-five were in the audience.

High-Speed Flight, Topic at Susquehanna Section

On April 14 a dinner meeting was held at the Brunswick Hotel, Lancaster, Pa. De Marquis D. Wyatt of the N.A.C.A. Laboratory, Cleveland, Ohio, gave a talk on "High-Speed Flight." Mr. Wyatt is in charge of the 18 and 20-in. supersonic wind tunnels at the laboratory. Officers elected for the coming season are: E. W. Gallenkamp, chairman; J. Wayne Deegan, vice-chairman; G. Dugan Johnson, vice-chairman; and Arra Steve Avakian, secretary-treasurer.

Instruments and Controls Discussed at Syracuse Section

On May 14 at the Technology Club, Syracuse, N. Y., an open discussion was held, led by F. G. Hensel of the Carrier Corporation, and D. V. Shetland of the Central New York Power Corporation, on "Instrumentation and Control." Mr. Hensel discussed definitions, terminology, and fundamentals of automatic controllers and systems, and Mr. Shetland discussed the automatic-control system for boiler feed pumps at the Oswego Steam Station of central New York Power Corporation. This complex subject stimulated much discussion.

Utah Section Hears Papers by Student Members

On April 30 at the University of Utah Union Building, Salt Lake City, Utah, two short papers were presented by graduating seniors of the A.S.M.E. Student Branch of the University of Utah. The first was entitled "Recent Developments in Parachute Artillery," by Reid Bills; and the second "Performance Test; Supercharged Diesel Engine," by Marshall Bell. Six additional student members of the branch were guests of the Section. The speakers presented actual data and experiences to supplement their papers. Twenty-four were present.

Western Washington Section Entertains Seniors of Student Branch

On May 7 at the Engineers Club, Seattle, Wash., the graduating seniors of the A.S.M.E. Student Branch of the University of Washington, were feted by the Section. Prof. E. O. Eastwood of the University, and past-chairman of the Section, past-vice-president and Fellow A.S.M.E., spoke to the students concerning

their "commencement" of an engineering career upon graduation. He said that each should strive to do the work he is best suited for and likes best, and to get the very most out of life and his profession as possible. Ira Dye, member A.S.M.E., past-chairman of the Section, spoke of the benefits of the A.S.M.E., and gave pointers to the Students on getting a job and improving their positions as time goes on.

A movie entitled "Amazon" was shown, illustrating the industrial development of that part of South America in past years. Seventy were in the audience.

West Virginia Section Holds two Meetings

On April 28 at the Daniel Boone Hotel, Charleston, W. Va., W. H. Rowand, member A.S.M.E., chief staff engineer, The Babcock & Wilcox Company, New York, N. Y., gave a talk on "Recent Boiler-Design Practice." Mr. Rowand said that the diversity of arrangement to provide highest efficiencies and availability for every situation of load, fuel, and feedwater, is the objective of modern boiler design. He showed slides of many boiler arrangements being offered today. The audience of 85 members and guests spend a profitable evening by being brought up-to-date on this subject of universal interest.

"Trends in Automotive Power Plants" was the subject heard at the May 26 meeting in the Daniel Boone Hotel, Charleston, W. Va. The speaker was Ralph M. Heintz, member A.S.M.E., vice-presicent, Jack & Heintz Precision Industries, Inc., Cleveland, Ohio. Starting with the wheels, Mr. Heintz invited his audience of 65 members and guests, to participate with him in an imaginative redesign of the automotible, to achieve better riding qualities, lightness, and economy. The last step in this redesign was the engine, as an example of which Mr. Heintz presented his firm's experimental 6-cylinder horizontally opposed model. Employing a die-cast integral cylinder and crankcase, and slide valve, this engine is a radical departure from the conventional automotive power plant. A stimulating discussion followed the talk.

Wilmington Sub-Section Elects Officers

On April 23 a dinner meeting was held in the Hob Tea Room, Wilmington, Del. O. R. Ames of the engineering department, E. I. du Pont de Nemours and Company, spoke on "Bomb Effects on the Japanese Chemical Industry." Mr. Ames expressed the opinion that inability to produce oil was one of the major flaws in the Japanese offensive and defensive armor. The speaker told of his visit as a member of an Air Force mission to Nagasaki, Hiroshima, and Tokyo.

The following slate of officers for 1947–1948, was unanimously approved by the membership attending the meeting: Walter E. Segal, chairman; Donald L. Arm, vice-chairman; A. P. Wendland, secretary-treasurer; F. H. McBerty, J. R. Chowning, and Walter Locke, executive committee.

Worcester Section Guests of Bay State Club

On May 7 members of the A.S.M.E. Worcester Section were guests of the Bay State and Foreman's Club, at a dinner at the Westborough Country Club. Mr. Buchner welcomed the group on behalf of the club. The A.S.M.E. was represented at the head table by F. E. Bailey, plant engineer, Crocker-Burbank Paper Company, Fitchburg, Mass., who is the outgoing chairman of the Section, and Ray Tolman, the newly elected chairman. After dinner, the party divided into seven groups for a tour of the plant, with Mr. Buckner, Don Wilson, Frank Hughes, Joe Collins, Lloyd Sweet, Rush Putnam, and Ed Farmer acting as guides. Following the tour, the film *The Bay State* was shown at the Recreation Hall. Bowling and pitch completed the program.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3.50 per quarter or $12 per annum, payable in advance.

New York	Chicago	Detroit	San Francisco
8 West 40th St.	211 West Wacker Drive	109 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

MECHANICAL ENGINEER, 32, married, B.S.M.E., M.M.E. Ten years' experience analysis and design. Thorough knowledge of structural analysis, good knowledge mathematics, dynamics, shop processes. At present supervising eight men. Desires more responsible position with more administrative work. Vicinity of Philadelphia. Me-188.

MECHANICAL ENGINEER, graduate, registered P.E. 26 years' diversified experience in responsible positions. Many patents issued in mechanical, electrochemical, and metallurgical processes. Director of research 5 years. Prefers position on West Coast or foreign, but will go anywhere. Me-189.

INDUSTRIAL ENGINEER with B.S. in I.E. from Lehigh University; age 28. Excellent college, military, and business record. Familiar with almost all phases of manufacturing organization. Experienced in systems and procedures, work, and sales administration. Primary interests, management engineering, sales management. Me-190.

MECHANICAL ENGINEER, graduate 1943; age 25. Four years' diversified experience in design, development, and research. Desires position as industrial designer. New York, N. Y., preferred. Me-191.

JUNIOR MECHANICAL ENGINEER, age 26. Graduate, June, 1947, veteran. Interested in design or production work. Five years' experience in mechanics, one year's experience as an inspector. Metropolitan area preferred. Me-192.

[1]All men listed hold some form of A.S.M.E. membership.

MECHANICAL ENGINEER, 28, single, B.S., B.S.M.E., M.M.E. Three years' experimental development work in metallurgy, related mechanical processes. One year teaching descriptive geometry. Desires permanent position. Me-193.

MECHANICAL ENGINEER. Ten years' experience in mechanical, chemical, and metallurgical processes and equipment; including development designing, plant layout, specification writing, and maintenance. Acted in supervisory and consultant capacity. Desires responsible position in New York, N. Y., or vicinity. Me-194.

TOOL ENGINEER, 32, graduate M.E. Ten years' design and production including five and a half years' diversified tooling training covering dies, jigs, fixtures, and gages for both sheet-metal and machined parts. Me-195.

PROJECT ENGINEER, 26, married; B.S.M.E., electronics training; five years' research, testing, design, development for production of intricate mechanical and electronic mechanical equipment, including air-borne and ground radar, servomechanisms, power equipment, air conditioning. Available June, 1947. Location preferred, Los Angeles area. Me-196-475-D-11-San Francisco, Calif.

POWER ENGINEER, chief or assistant; 46, married; experienced in operation and maintenance of mechanical, electrical, and hydraulic equipment of any size or complexity. Opportunity for advancement more important than starting position. Available on short notice. Location is not too important. Me-197-474-D-13-San Francisco, Calif.

MECHANICAL ENGINEER, graduate, ex-naval officer, young; six years' steam-power design

and maintenance experience. Power surveys, reports, specifications, design, purchasing, etc. Experienced with high-pressure steam for industrial plants. Me-198.

MECHANICAL ENGINEER, B.S.M.E., Cornell; married, 28. Engineering—executive experience in heavy and precision manufacturing. Knows machine tools, manufacturing methods, cost systems, business procedures. Interested in industrial expansion of Pacific Northwest. Me-199-475-D-8-San Francisco, Calif.

ENGINEER, 35, married; good theoretical and practical background for research and development work. Experience on machinery, structures, and electric circuits. Original, resourceful, energetic, good organizer. Available August. Location preferred, West Coast. Me-200-444-D-1-San Francisco, Calif.

POSITIONS AVAILABLE

INSTRUCTORS of various ranks for rapidly developing school of engineering. Men with advanced degrees, teaching, or professional experience desired. Openings in civil, mechanical, metallurgical, and electrical engineering. Massachusetts. W-8923.

SALES REPRESENTATIVE, 25–30, for manufacturer of cranes, hoists, and special machines. Must have some engineering background and sales personality. Six months' training in plant in Michigan to acquaint applicant with company's products and procedure. Territory, New York, N. Y. W-9083.

MECHANICAL ENGINEER, under 35, graduate, with 3 to 5 years' experience, or graduate work as alternative, in the field of heating-and-ventilation testing and design. Should have sound knowledge of fundamentals of thermodynamics and heat and fluid flow, and a special aptitude for research. Ability in creative design and analyses of thermal problems essential. $4200–$5600. Northern New Jersey. W-9093.

DEVELOPMENT ENGINEER to develop sound-recording methods and equipment particularly applied to disk recording; make theoretical analysis; application of physical data and measurements to design of electromechanical systems. Should know fundamental physics, mechanics, electronics, and magnetism, etc. Salary open. Southern New Jersey. W-9104(*a*).

ASSISTANT SALES MANAGER with some outside sales experience, above average ability in letter writing and composition. About $5000. Ohio. W-9107.

ENGINEER with sufficient experience to take charge of small groups, and with ability to progress rapidly into a position as chief assistant, for manufacturer of dredging pumps and machinery. Should have broad experience in machinery design, arrangement, and installation, and some piping and electrical-layout experience, if possible. Good opportunity. Start $4800–$5400. Maryland. W-9111.

MECHANICAL ENGINEER, 35–50, with highly diversified shop training and practical experience in toolmaking, tool grinding, tool designing, manufacturing methods, and brass-foundry practice; also experience in estimating tool and manufacturing costs, tool controls, and up-to-date on development in cutting tools, machine tools, and equipment, as well as welding techniques, cleaning and finishing methods, and procedures. Connecticut. W-9116.

DISTRICT SALES MANAGER for manufacturer of industrial heating equipment, i.e., rotary burners, steam generators, etc. Must have considerable engineering and sales background. $8000–$10,000. Territories: New England, New York, South, and Midwest. Headquarters Pennsylvania. W-9119.

MECHANICAL ENGINEER, under 50, to act in supervisory capacity in tin smelter. Should have good general-management and smelter experience. Southwest. W-9131.

SALES ENGINEER, electrical or mechanical graduate, with air-conditioning or dust-control experience, to represent manufacturer of electrostatic precipitators and cover Eastern States. $4800–$6000. W-9136.

SAFETY ENGINEER, 35–45, with 5 to 10 years' experience on industrial safety work, plus some experience in chemical safety work. Salary, $10,000–$12,000 year. East. W-9145.

ASSISTANT TO PERSONNEL MANAGER, 30–40, business administration or industrial-engineering degree, preferably with law degree also, with 3 years' experience in labor relations and personnel administration, to attend meetings and make notes at grievance and labor-relations meetings. $4000–$5000 year. Virginia. W-9158.

PLANT ENGINEER, graduate, with experience as plant engineer or with contractor on construction of chemical plants, to supervise maintenance and construction personnel, including an engineering department. Will supervise about 270 employees. Salary open. Arkansas. W-9161.

ENGINEERS. (*a*) Lubrication engineer, graduate preferred, with experience in lubrication applications to industrial machinery. Must have a knowledge of lubricants and their uses. Maximum $7200. (*b*) Packaging engineer, 35 or younger, with technical knowledge of corrugated-carton manufacturing and a general knowledge of glass, metal, and wood containers. $4200. Pennsylvania. W-9164.

ASSISTANT CHIEF ENGINEER, graduate, 30–35, with 8 to 10 years' experience in design and application of power-transmission equipment and some hydraulic experience. Any machine-shop or foundry experience would be helpful. About $5200. South central Pennsylvania. W-9171.

WORKS MANAGER, 30–45, for general supervision of complete manufacturing facilities, including aluminum and bronze foundry, heat-treating equipment, production machine shop, and toolroom, for manufacturer of electrical distribution fittings. Must have good record of operating results in quality, production, and cost. Salary open. Alabama. W-9180.

PLANT MANAGER, 38–50, mechanical graduate, for steel company. Must have had experience in foundry work on bronze, steel, and iron, and some machine-shop experience. Must thoroughly understand complex tools and fixtures. $12,000–$15,000, plus bonus. Ohio. W-9181.

MECHANICAL ENGINEER with experience in calculations for gear-reduction mechanisms and antifriction bearings, and thoroughly familiar with materials, heat-treatments, castings, steel fabrication, and other manufacturing processes, for product design and supervisory work. Write giving full details and salary expected. Ohio. W-9188(a).

PATENT ATTORNEY, 30–45. Must have law degree and a technical background. Must be able to write patent specifications, prosecute applications, etc. New York, N. Y. W-9197.

INDUSTRIAL ENGINEER, mechanical- or industrial-engineering graduate, with considerable experience in wage and salary administration, job evaluations, and job analysis, as well as wide experience in the development and administration of incentive and bonus systems. Experience in methods work desired as well as some knowledge of paper and pulp industry. $6000–$7000 year. Louisiana. W-9203.

ASSISTANT CHIEF INDUSTRIAL ENGINEER, industrial- or management-engineering graduate, with broad experience in comprehensive program of management engineering including study and analysis of methods and procedures, equipment, layout, standards, controls, personnel, markets, operations, and costs, to direct and co-ordinate activities of manufacturing, sales, office, and transportation personnel. $7900–$9650 year. Pennsylvania. W-9212.

MECHANICAL ENGINEER or practical mechanic having considerable experience with mining companies in general construction work, mining- and milling-plant maintenance including Diesel engines, milling equipment, compressors, hoists, pumps, etc., to act as construction superintendent and later take charge of mechanical and electrical departments. Salary open. Mexico. W-9218.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after July 25, 1947, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Fellow, Member, Associate, or Junior

ABBOTT, WALTER R., JR., Louisville, Ky.
ANTONSEN, ANKER K., Beloit, Wis.